ECTOPARASITES AND HELMINTHS OF DOVES AND PIGEONS (AVES: COLUMBIDAE) IN ZARIA, NIGERIA

BY

ADANG, KOMBE LUCAS B. Sc. (ABU 1995), M. Sc. (ABU 1999)
Ph.D./Sci/ 23367/00-01

A DISSERTATION SUBMITTED TO THE POSTGRADUATE SCHOOL, AHMADU BELLO UNIVERSITY, ZARIA NIGERIA

IN PARTIAL FULFILMENT FOR THE AWARD OF DOCTOR OF PHILOSOPHY IN ZOOLOGY

DEPARTMENT OF BIOLOGICAL SCIENCES
FACULTY OF SCIENCE
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA

OCTOBER, 2007

DECLARATION

I declare that the work in the disserttion entitled "Ectoparasites and Helminths of Doves and Pigeons (Aves: Columbidae) in Zaria, Nigeria" has been performed by me in the Department of Biological Sciences under the supervision of Profs. S. J. Oniye, A. U. Ezealor, P. A. Abdu and O. J. Ajanusi.

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at any university.

Adang, kombe Lucas	_____	October 30, 2007
Name of student	Signature	Date

CERTIFICATION

This dissertation entitled "ECTOPARASITES AND HELMINTHS OF DOVES AND PIGEONS (AVES: COLUMBIDAE) IN ZARIA, NIGERIA" by Adang, Kombe Lucas meets the regulations governing the award of Doctor of Philosophy of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

Prof. S. J. Oniye
Chairman, Supervisory Committee
Dept. of Biological Sciences

Date

Prof. A. U. Ezealor
Member, Supervisory Committee
Dept. of Biological Sciences

Date

Prof. P. A. Abdu
Member, Supervisory Committee
Dept. of Veterinary Surgery and Medicine

Date

Prof. O. J. Ajanusi
Member, Supervisory Committee
Dept. of Veterinary Parasitoloy and Entomology

Date

Prof. A. U. Ezealor
Head of Department

Date

Prof. S. A. Nkom
Dean, Postgraduate School

Date

ACKNOWLEDGEMENTS

I give God first place in this acknowledgement for the wisdom, knowledge and understanding accorded me to have gone successfully through this programme. To him, be all the honour, glory and adoration.

I am indebted to my team of supervisors comprising of Profs. S. J. Oniye, A. U. Ezealor, P. A. Abdu and O. J. Ajanusi for their encouragement and painstakingly going through this manuscript.

I wish to acknowledge with gratitude the assistance of Drs. Fatihu, M. Y., Wakawa, M. A. and Musa Milton all of the Faculty of Veterinary Medicine A.B.U., Zaria, for their assistance during the experimental phase. I am grateful to Prof. N.D.G. Ibrahim and Mr. Francis Udekwe all of Veterinary Pathology and Microbiology, for the histopathology analysis and report. I also acknowledge with gratitude the assistance of Alhaji Sale Usman, Alhaji Bala Musa, Mr. Daniel Gimba and Mr. Samuel Otobo all of Veterinary Parasitology and Entomology for technical assistance, particularly in the identification of the parasites. I acknowledge the contributions of Mr. Joseph Arumona and Mr. Cletus Umaru who assisted me in photography and photomicrography.

Special appreciation to my wife, Mrs. Miranda A. Adang, nee Ane Binda for her love, care and support, and for her active participation at the experimental phase of this work. It suffices therefore to say, “Behind every successful man, there is an “active” woman”.

To my friends, Mrs. Bambot Grace, Mrs. Lucy Aghangu, Mr. Kum Cletus, all of the University of Dschang, Cameroon, Dr. and Mrs. Njiforti Peter, Mr. and Mrs. Kimeng H. T., Dr. and Mrs. Fru Francis, Mr. and Mrs. Ndokwo Joseph, Prof. and Mrs. Alisa, Dr. and Mrs. C. A. Awasum, all of A.B.U., Zaria, Mr. and Mrs. Fonda Solomon of Nasarawa State University, Keffi, Dr. Delphine Mbinka, Mr. and Mrs. Mbafor Christopher and Mr. and Mrs. Chii Emmanuel of Adamawa State University, Mubi, Mr. and Mrs. Pius Agyingi of Cooperative College Bamenda, Cameroon, Mr. and Mrs. Aparandi Mathew of Maryland, USA, Mr. Bang Henry of the University of East Anglia, UK and Mrs. Lucy George Lekunze

of East Orange, USA and a host of others too numerous to mention for their moral, financial and material support, I appreciate you.

I owe gratitude to my former colleagues at the St. Joseph's Minor Seminary, Zaria and my present colleagues at the Gombe State University, Gombe for their encouragement.

I am highly grateful to the entire ADANG family and associates and my in-laws, the Binda's family, for their prayers, moral, financial and material support.

Special appreciation to my brothers Mr. Joseph Adang and Mr. Barnabas Adang and to my uncle Mr. Akemecha David, who from their meager resources, sponsored me to this level. Special appreciations to my Mother and Mother-in-law, for their motherly support and encouragement. I remain indebted to you all.

To the Chaplaincy, Council, Redemption choir and the entire members of the Chapel of Redemption, A.B.U., Zaria and to the Ministers and entire members of the Presbyterian Church of Nigeria, Gombe, I say, God bless you all for your prayers and spiritual support. "Our God is good and he is good all the time".

I acknowledge the contributions of the following young men who assisted as typists at one time or the other, Mess Innocent Babila, Elvis Babila, Fritz Abam Nyanga, Ngo Vallery, Pride Njeati and Chia Mathias.

I acknowledge, though posthumously, but with total submission to the will of God, the contributions of my late sister Mrs. Egeandong Elizabeth Mandi nee Adang to whose blessed memory this dissertation is dedicated and my late aunty Mrs. Akemecha Comfort nee Bang, for all their efforts and encouragement. Unfortunately, they could not live long to reap the fruits of their labours. Similarly, the encouragement of my departed friend, Late Dr. J. A. Karl Wunde is appreciated. May their souls continue to rest in peace- Amen.

ABSTRACT

A total of seven hundred and thirty six Columbids from Zaria and its environs were examined for ectoparasites and helminths from March 2002 - February 2004. The ectoparasites recovered comprised of lice: *Columbicola columbae* 229 (31.1%), *Menopon gallinae* 87 (11.8%), *Goniodes* species 44 (6.0%); fly: *Pseudolynchia canariensis* 127 (17.5%); mite: *Dermanyssus gallinae* 7 (1.0%) and tick: *Argas persicus* 14 (1.9%). The percentage of mixed infestation was higher than that of single infestation in *Columba livia domestica*, *Streptopelia decipiens*, *Columba guinea* and *Streptopelia vinacea* while that of single infestation was higher than that of mixed infestation in *Streptopelia senegalensis* and *Turtur abyssinicus*. Chi square test showed no significant association between sex and ectoparasite infestation in all the Columbids ($P>0.05$) but showed a significant association between the wet season and ectoparasite infestation ($P<0.05$) in *Columba livia domestica* and *Streptopelia senegalensis*.

The helminths identified, included cestodes: *Raillietina tetragona* 154 (20.9%), *Raillietina echinobothrida* 100 (13.6%), *Raillietina magninumida* 15 (2.0%), *Raillietina cesticillus* 37 (5.0%), *Amoebotaenia cuneata* 25 (3.4%), *Hymenolepis carioca* 39 (5.3%) and *Hymenolepis cantaniana* 46 (6.3%) and the nematodes: *Heterakis gallinarum* 11 (1.5%), *Ascaridia galli* 10 (1.4%) and *Ascaridia columbae* 27 (3.7%). New hosts records were obtained for *Raillietina magninumida, Hymenolepis cantaniana* and *Heterakis gallinarum*. The percentage of single infection was higher than that of mixed infection in all the six Columbids. Chi square test showed no significant association between sex and helminth infections in all the Columbids ($P>0.05$) but showed a significant association between the wet season and helminthiasis ($P<0.05$) in *Columba livia domestica* and *Streptopelia senegalensis*.

The effect of *Ascaridia galli* in *Columba livia domestica* was studied and clinical signs observed in the infected birds were blood-tinged diarrhoea, inappetance, dropsy looks, ruffled

feathers, shivering and emaciation. At the termination of the experiment, 12 weeks after infection, a significant difference in weekly body weight changes ($P<0.05$) was observed in the infected group. However, there was no significant difference ($P>0.05$) in the weekly packed cell volume, haemoglobin level and total plasma protein in the infected group. At necropsy, a total of 87 worms were recovered from 14 of the 30 birds infected and none from the controls. Histopathologic analysis of the organs showed mononuclear and polymorphonuclear cellular infiltrations in the necrotized areas of the liver, the lungs had haemorrhagic areas, congested blood vessels and haemosiderosis. The heart showed focal areas of necrosis of the myocardial cells and few mononuclear and polymorphonuclear cells in the necrotized areas, the kidneys had renal tubular necrosis infiltrated by few mononuclear and polymorphonuclear cells and there was necrosis of the intestine that involved the villi, intestinal glands and the muscularis mucosa. The study concludes that Columbids in Zaria, Nigeria, harbour ectoparasites and helminths of veterinary importance. The study recommends that for any effective control programme, domestic pigeons should be treated along side poultry since the pigeons may serve as reservoir or alternative hosts to poultry parasites. The experiment on infection of *Columba livia domestica* with *Ascaridia galli* using squabs may give alternate clinical and pathological information.

TABLE OF CONTENTS

Title Page i

Declaration ii

Certification iii

Acknowledgements iv

Abstract vii

Contents x

List of Tables xviii

List of Figures xxii

List of Plates xxiv

List of Appendices xxvi

Abbreviations, Definitions, Glossaries and Symbols xxix

Chapter 1

1.0 Introduction 1

Chapter 2

2.0 Literature Review 5

2.1The family Columbidae 5

2.2 Description of Some Columbids 5

2.3 Parasites of Columbids 15

2.3.1 Ectoparasites 15

Lice 15

Mites 20

Ticks 22

Bugs 24

Fleas 25

Flies 26

2.3.2 Helminths 27

Trematodes 27

Cestodes 29

Nematodes 33

Acanthocephala .....

Chapter 3

3.0 Materials and Methods 38

3.1 Study area, trapping and identification of Columbids 38

3.2 Columbids sampled 39

3.3 Sex determination 39

3.4 Weight determination 39

3.5 Determination of packed cell volume (PCV) 39

3.6 Screening for ectoparasites 40

3.7 Screening for helminths 40

3.8 Experimental infection of *Columba livia domestica* with *Ascaridia galli* 41

3.8.1 Experimental birds 41

3.8.2 Production of infective eggs of *Ascaridia galli* 42

3.8.3 Infection of birds with infective eggs 43

3.8.4 Histopathology 44

3.9 Data and Statistical analysis 45

3.10 Photography and Photomicrography 46

Chapter 4

4.0 Results 47

4.1 Ectoparasites of *Columba livia domestica* 47

4.1.1 Prevalence of ectoparasites 47

4.1.2 Intensity of ectoparasite infestations 54

4.1.3 Frequency distribution of single and mixed ectoparasite infestations 54

4.1.4 Sex-related ectoparasite infestations of *Columba livia domestica* 54

4.1.5 Effects of ectoparasite infestations on body weight and PCV 54

4.1.6 Monthly prevalence of ectoparasites 59

4.2 Helminths of *Columba livia domestica* 63

4.2.1 Prevalence of helminths 63

4.2.2 Intensity of helminth infections 74

4.2.3 Frequency distribution of single and mixed helminth infections 74

4.2.4 Sex-related helminth infections of *Columba livia domestica* 74

4.2.5 Effects of helminth infections on body weight and PCV 79

4.2.6 Monthly prevalence of helminths 79

4.3 Ectoparasites of *Streptopelia senegalensis* 83

4.3.1 Prevalence of ectoparasites 83

4.3.2 Intensity of ectoparasite infestations 84

4.3.3 Frequency distribution of single and mixed ectoparasite infestations 84

4.3.4 Sex-related ectoparasite infestations of Streptopelia senegalensis 84

4.3.5 Effects of ectoparasite infestations on body weight and PCV 91

4.3.6 Monthly prevalence of ectoparasites 91

4.4 Helminths of *Streptopelia senegalensis* 95
4.4.1Prevalence of helminths 95
4.4.2 Intensity of helminth infections 99
4.4.3 Frequency distribution of single and mixed helminth infections 99
4.4.4 Sex-related helminth infections of *Streptopelia senegalensis* 99
4.4.5 Effects of helminth infections on body weight and PCV 104
4.4.6 Monthly prevalence of helminths 104
4.5 Ectoparasites of *Streptopelia decipiens* 109
4.5.1 Prevalence of ectoparasites 109
4.5.2 Intensity of ectoparasite infestations 110
4.5.3 Frequency distribution of single and mixed ectoparasite infestations 110
4.5.4 Sex-related ectoparasite infestations of *Streptopelia decipiens* 113
4.5.5 Effects of ectoparasite infestations on body weight and PCV 113
4.5.6 Monthly prevalence of ectoparasites 113
4.6 Helminths of *Streptopelia decipiens* 117
4.6.1Prevalence of helminths 117
4.6.2 Intensity of helminth infections 119
4.6.3 Frequency distribution single and mixed helminth infections 119
4.6.4 Sex-related helminth infections of *Streptopelia decipiens* 119
4.6.5 Effects of helminth infections on body weight and PCV 120
4.6.6 Monthly prevalence of helminths 120
4.7 Ectoparasites of *Columba guinea* 126
4.7.1 Prevalence of ectoparasites 126
4.7.2 Intensity of ectoparasite infestations 127

4.7.3 Frequency distribution of single and mixed ectoparasite infestations 127
4.7.4 Sex-related ectoparasite infestations of *Columba guinea* 127
4.7.5 Effects of ectoparasite infestations on body weight and PCV 133
4.7.6 Monthly prevalence of ectoparasites 133
4.8 Helminths of *Columba guinea* 136
4.8.1Prevalence of helminths 136
4.8.2 Intensity of helminth infections 138
4.8.3 Frequency distribution of single and mixed helminth infections 138
4.8.4 Sex-related helminth infections of *Columba guinea* 139
4.8.5 Effects of helminth infections on body weight and PCV 144
4.8.6 Monthly prevalence of helminths 144
4.9 Ectoparasites of *Turtur abyssinicus* 146
4.9.1 Prevalence of ectoparasites 146
4.9.2 Intensity of ectoparasite infestations 147
4.9.3 Frequency distribution of single and mixed ectoparasite infestations 147
4.9.4 Sex-related ectoparasite infestations of Turtur abyssinicus 147
4.9.5 Effects of ectoparasite infestations on body weight and PCV 153
4.9.6 Monthly prevalence of ectoparasites 153
4.10 Helminths of *Turtur abyssinicus* 155
4.10.1Prevalence of helminths 155
4.10.2 Intensity of helminth infections 156
4.10.3 Frequency distribution of single and mixed helminth infections 156
4.10.4 Sex-related helminth infections of *Turtur abyssinicus* 156
4.10.5 Effects of helminth infections on body weight and PCV 162

4.10.6 Monthly prevalence of helminths 162

4.11 Ectoparasites of *Streptopelia vinacea* 164

4.11.1 Prevalence of ectoparasites 164

4.11.2 Intensity of ectoparasite infestations 165

4.11.3 Frequency distribution of single and mixed ectoparasite infestations 165

4.11.4 Sex-related ectoparasite infestations of Streptopelia vinacea 165

4.11.5 Effects of ectoparasite infestations on body weight and PCV 171

4.11.6 Monthly prevalence of ectoparasites 171

4.12 Helminth parasites of *Streptopelia vinacea* 173

4.12.1 Prevalence of helminths 173

4.12.2 Intensity of helminth infections 174

4.12.3 Frequency distribution of single and mixed helminth infections 174

4.12.4 Sex-related helminth infections of *Streptopelia vinacea* 178

4.12.5 Effects of helminth infections on body weight and PCV 178

4.12.6 Monthly prevalence of helminths 178

4.13 Experimental infection of *Columba livia domestica* with *Ascaridia galli* 182

4.13.1 Changes in body weights 182

4.13.2 Changes in Packed Cell Volume (PCV) 182

4.13.3 Changes in Haemoglobin level (Hb) 185

4.13.4 Changes in Total plasma protein 185

4.13.5 Clinical signs 188

4.13.6 Worm recovery 188

4.13.7 Histopathology 188

Chapter 5

5.0 Discussion 195

5.1 Ectoparasites of Columbids 195

5.1.1 Prevalence of ectoparasites on Columbids 195

5.1.2 Intensity of ectoparasite infestations on Columbids 198

5.1.3 Frquency distribution of single and mixed ectoparasite infestations 198

5.1.4 Sex-related ectoparasite infestations of Columbids 199

5.1.5 Effects of ectoparasite infestations on body weight and PCV 199

5.1.6 Monthly prevalence of ectoparasites on Columbids 200

5.2 Helminth of Columbids 207

5.2.1 Prevalence of helminths in Columbids 207

5.2.2 Intensity of helminth infections in Columbids 210

5.2.3 Frequency distribution of single and mixed helminth infections 211

5.2.4 Sex-related helminth infections of Columbids 212

5.2.5 Effects of helminth infections on body weight and PCV 213

5.2.6 Monthly prevalence of helminths in Columbids 215

5.3 Experimental infection of *Columba livia domestica* with *Ascaridia galli* 218

Chapter 6

6.0 Summary, Conclusions and Recommendations 220

6.1 Summary 220

6.2 Conclusions 222

6.3 Recommendations 223

References 225

Appendices 236

LIST OF TABLES

Table 4.1: Prevalence and predilection sites of ectoparasites of *Columba livia domestica* in Zaria, Nigeria 48

Table 4.2: Intensity of ectoparasite infestations on *C. l. dommestica* in Zaria, Nigeria 55

Table 4.3: Frequency distribution of single and mixed ectoparasite infestations on *C. l. domestica* in Zaria, Nieria 56

Table 4.4: Prevalence of ectoparasites of male *C. l. domestica* in Zaria, Nigeria 57

Table 4.5: Prevalence of ectoparasites of female *C. l. domestica* in Zaria, Nigeria 58

Table 4.6: Prevalence and predilection site of intestinal helminths of *C. l. domestica* in Zaria, Nigeria 64

Table 4.7: Intensity of helminth infections in *C. l. domestica* in Zaria, Nigeria 75

Table 4.8: Frequency distribution single and mixed infections of helminths in *C. l. domestica* in Zaria, Nigeria 76

Table 4.9: Prevalence and predilection site of intestinal helminths of male *C. l. domestica* in Zaria, Nigeria 77

Table 4.10: Prevalence and predilection site of intestinal helminths of female *C. l. domestica* in Zaria, Nigeria 78

Table 4.11: Prevalence and predilection site of ectoparasites of *Streptopelia senegalensis* in Zaria, Nigeria 86

Table 4.12: Intensiry of ectoparasite infestations on *S. senegalensis* in Zaria, Nigeria 87

Table 4.13: Frequency distribution single and mixed ectoparasite infestations on *S. senegalensis* in Zaria, Nigeria 88

Table 4.14: Prevalence and predilection site of ectoparasites of male *S. senegalensis* in Zaria, Nigeria 89

Table 4.15: Prevalence and predilection site of ectoparasites of female *S. senegalensis* in Zaria, Nigeria 90

Table 4.16: Prevalence and predilection site of intestinal helminths of *S. senegalensis* in Zaria, Nigeria 98

Table 4.17: Intensity of helminth infections in *S. senegalensis* in Zaria, Nigeria 100

Table 4.18: Frequency distribution of single and mixed helminth parasite infections in *S. senegalensis* in Zaria, Nigeria..... 101

Table 4.19: Prevalence and predilection site of intestinal helminths of male *S. senegalensis* in Zaria, Nigeria 102

Table 4.20: Prevalence and predilection site of intestinal helminths of female *S. senegalensis* in Zaria, Nigeria 103

Table 4.21: Prevalence and predilection sites of ectoparasites of *Streptopelia decipiens* in Zaria, Nigeria..... 110

Table 4.22: Intensity of ectoparasite infestations in *S. decipiens* in Zaria, Nigeria..... 111

Table 4.23: Frequency distribution of single and mixed ectoparasite infestations on *S. decipiens* in Zaria, Nigeria..... 112

Table 4.24: Prevalence and predilection sites of ectoparasites of male *S. decipiens* in Zaria, Nigeria..... 114

Table 4.25: Prevalence and predilection sites of ectoparasites of female *S. decipiens* in Zaria, Nigeria..... 115

Table 4.26: Prevalence and predilection sites of intestinal helminths of *S. decipiens* in Zaria, Nigeria..... 118

Table 4.27: Intensity of helminth infections in *S. decipiens* in Zaria, Nigeria 121

Table 4.28: Frequency distribution single and mixed helminth infections in *S. decipiens* in Zaria 122

Table 4.29: Prevalence and predilection sites of intestinal helminths of male *S. decipiens* in Zaria, Nigeria 123

Table 4.30: Prevalence and predilection sites of intestinal helminths female of *S. decipiens* in Zaria, Nigeria 124

Table 4.31: Prevalence and predilection sites of ectoparasites of *Columba guinea* in Zaria, Nigeria..... 128

Table 4.32: Intensity of ectoparasite infestatins on *C. guinea* in Zaria, Nigeria 129

Table 4.33: Frequency distribution of single and mixed ectoparasite infestations on *C. guinea* in Zaria, Nigeria 130

Table 4.34: Prevalence and predilection sites of ectoparasites of male *C. guinea* in Zaria, Nigeria 131

Table 4.35: Prevalence and predilection sites of ectoparasites of female *C. guinea* in Zaria, Nigeria 132

Table 4.36: Prevalence and predilection sites of intestinal helminths of *C. guinea* in Zaria, Nigeria 137

Table 4.37: Intensity of helminth infections in *C. guinea* in Zaria, Nigeria 140

Table 4.38: Frequency distribution of single and mixed helminth infections in *C. guinea* in Zaria, Nigeria 141

Table 4.39: Prevalence and predilection sites of intestinal helminths of male *C. guinea* in Zaria, Nigeria 142

Table 4.40: Prevalence and predilection sites of intestinal helminths of female *C. guinea* in Zaria, Nigeria 143

Table 4.41: Prevalence and predilection sites of ectoparasite of *Turtur abyssinicus* in Zaria, Nigeria 148

Table 4.42: Intensity of ectoparasite infestations in *T. abyssinicus* in Zaria, Nigeria 149

Table 4.43: Frequency distribution of single and mixed ectoparasite infestations on *T. abyssinicus* in Zaria, Nigeria 150

Table 4.44: Prevalence and predilection sites of ectoparasite of male *T. abyssinicus* in Zaria, Nigeria 151

Table 4.45: Prevalence and predilection sites of ectoparasite of female *T. abyssinicus* in Zaria, Nigeria 152

Table 4.46: Prevalence and predilection sites of intestinal helminths of *T. abyssinicus* in Zaria, Nigeria 157

Table 4.47: Intensity of helminth infections in *T. abyssinicus* in Zaria, Nigeria 158

Table 4.48: Frequency distribution of single and mixed helminth infections in *T. abyssinicus* in Zaria, Nigeria 159

Table 4.49: Prevalence and predilection sites of intestinal helminths of male *T. abyssinicus* in Zaria, Nigeria 160

Table 4.50: Prevalence and predilection sites of intestinal helminths of female *T. abyssinicus* in Zaria, Nigeria 161

Table 4.51: Prevalence and predilection sites of ectoparasites of *Streptopelia vinacea* in Zaria, Nigeria 166

Table 4.52: Intensity of ectoparasite infestations in *S. vinacea* in Zaria, Nigeria 167

Table 4.53: Frequency distribution of single and mixed ectoparasite infestations on *S. vinacea* in Zaria, Nigeria 168

Table 4.54: Prevalence and predilection sites of ectoparasites of male *S. vinacea* in Zaria, Nigeria 169

Table 4.55: Prevalence and predilection sites of ectoparasites of female *S. vinacea* in Zaria, Nigeria 170

Table 4.56: Prevalence and predilection sites of helminths of *S. vinacea* in Zaria, Nigeria 175

Table 4.57: Intensity of helminth infections in *S. vinacea* in Zaria, Nigeria 176

Table 4.58: Frequency distribution of single and mixed helminth infections in *S. vinacea* in Zaria, Nigeria 177

Table 4.59: Prevalence and predilection sites of helminths of male *S. vinacea* in Zaria, Nigeria 179

Table 4.60: Prevalence and predilection sites of helminths of female *S. vinacea* in Zaria, Nigeria 180

LIST OF FIGURES

Figure 4.1: Total monthly prevalence of ectoparasites on *C. l. domestica* in Zaria, Nigeria (2002 – 2004) 60

Figure 4.2: Monthly prevalence of individual ectoparasites on *C. l. domestica* in Zaria, Nigeria 61

Figure 4.3: Total monthly prevalence of helminths in *C. l. domestica* in Zaria, Nigeria (2002 – 2004) 80

Figure 4.4: Monthly prevalence of individual helminths in *C. l. domestica* in Zaria, Nigeria 81

Figure 4.5: Total monthly prevalence of ectoparasites on *S. senegalensis* in Zaria, Nigeria (2002 – 2004) 92

Figure 4.6: Monthly prevalence of individual ectoparasites on *S. senegalensis* in Zaria, Nigeria 93

Figure 4.7: Total monthly prevalence of helminths in *S. senegalensis* in Zaria, Nigeria (2002 – 2004) 105

Figure 4.8: Monthly prevalence of individual helminths on *S. senegalensis* in Zaria, Nigeria 106

Figure 4.9: Monthly prevalence of individual ectoparasites on *S. decipiens* in Zaria, Nigeria 116

Figure 4.10: Monthly prevalence of individual helminths in *S. decipiens* in Zaria, Nigeria 125

Figure 4.11: Monthly prevalence of individual ectoparasites on *C. guinea* in Zaria, Nigeria 135

Figure 4.12: Monthly prevalence of individual helminths in *C. guinea* in Zaria, Nigeria 145

Figure 4.13: Monthly prevalence of individual ectoparasites on *T. abyssinicus* in Zaria, Nigeria 154

Figure 4.14: Monthly prevalence of individual helminths in *T. abyssinicus* in Zaria, Nigeria 163

Figure 4.15: Monthly prevalence of individual ectoparasites on *S. vinacea* in Zaria, Nigeria 172

Figure 4.16: Monthly prevalence of individual helminths in *S. vinacea* in Zaria, Nigeria ... 181

Figure 4.17: Weekly mean body weights of infected and non- infected pigeons 183

Figure 4.18: Weekly mean PCV of infected and non- infected pigeons 184

Figure 4.19: Weekly mean of Hb level of infected and non- infected pigeons 186

Figure 4.20: Weekly mean of total plasma protein of infected and non- infected pigeons ... 187

LIST OF PLATES

Plate I: *Columba livia domestica* (Domestic Pigeon) 7

Plate II: *Streptopelia senegalensis* (Laughing Dove) 8

Plate III: *Streptopelia decipiens* (African-mourning Dove) 10

Plate IV: *Columba guinea* (Speckled Pigeon) 11

Plate V: *Turtur abyssinicus* (Black-billed wood Dove) 13

Plate VI: *Streptopelia vinacea* (Vinaceous Dove) 14

Plate VII: Anterior and posterior ends of *Columbicola columbae* 49

Plate VIII: Anterior and posterior ends of *Menopon gallinae* 50

Plate IX: Anterior and posterior ends of *Goniodes* sp 51

Plate X: *Pseudolynchia canariensis* (Pigeon fly) 52

Plate XI: Anterior and posterior ends of *Dermanyssus gallinae* 53

Plate XII: Anterior end of *Raillietina tetragona* 65

Plate XIII: Anterior end of *Raillietina echinobothrida* 66

Plate XIV: Anterior end of *Raillietina cesticillus* 67

Plate XV: Anterior end of *Amoebotaenia cuneata* 68

Plate XVI: Anterior end of *Hymenolepis carioca* 69

Plate XVII: Anterior end of *Hymenolepis cantaniana* 70

Plate XVIII: Anterior end of *Heterakis gallinarum* 71

Plate XIX: Anterior end of *Ascaridia galli* 72

Plate XX: Anterior end of *Ascaridia columbae* 73

Plate XXI: Anterior and posterior ends of *Argas persicus* 85

Plate XXII: Anterior end of *Raillietina magninumida* 97

Plate XXIII: Photomicrograph of a section of the liver from an infected pigeon 190

Plate XXIV: Photomicrograph of a section of the lung from an infected pigeon 191

Plate XXV: Photomicrograph of a section of the heart from an infected pigeon 192

Plate XXVI: Photomicrograph of a section of the kidney from an infected pigeon 193

Plate XXVII: Photomicrograph of a section of the intestine from an infected pigeon 194

LIST OF APPENDICES

Appendix 1: Prevalence of ectoparasites on Columbids in Zaria, Nigeria 236

Appendix 2: Prevalence of ectoparasites on male and female Columbids in Zaria, Nigeria 237

Appendix 3: Numbers, intensties and ranges of ectoparasites recovered from Columbids in Zaria, Nigeria 238

Appendix 4: Numbers, mean intensities and ranges of ectoparasites recovered from male and female Columbids in Zaria, Nigeria 239

Appendix 5: Prevalence of helminths in Columbids in Zaria, Nigeria 240

Appendix 6: Prevalence of helminths in male and female Columbids in Zaria, Nigeria 241

Appendix 7: Numbers, intensties and ranges of helminths recovered from Columbids in Zaria, Nigeria 242

Appendix 8: Numbers, mean intensities and ranges of helminths recovered from male and female Columbids in Zaria, Nigeria 243

Appendix 9: Monthly prevalence, intensity and mean monthly intensity of ectoparasites on *C. l. domestica* in Zaria 244

Appendix 10: Monthly prevalence, intensity and mean monthly intensity of helminths in *C. l. domestica* in Zaria 245

Appendix 11: Monthly prevalence, intensity and mean monthly intensity of ectoparasites on *S. senegalensis* in Zaria 247

Appendix 12: Monthly prevalence, intensity and mean monthly intensity of helminths in *S. senegalesis* in Zaria 248

Appendix 13: Monthly prevalence, intensity and mean monthly intensity of ectoparasites on *S. decipiens* in Zaria 250

Appendix 14: Monthly prevalence, intensity and mean monthly intensity of helminths in *S. decipiens* in Zaria 251

Appendix 15: Monthly prevalence, intensity and mean monthly intensity of ectoparasites on *C. guinea* in Zaria 252

Appendix 16: Monthly prevalence, intensity and mean monthly intensity of helminths in *C. guinea* in Zaria 253

Appendix 17: Monthly prevalence, intensity and mean monthly intensity of ectoparasites on *T. abyssinicus* in Zaria 254

Appendix 18: Monthly prevalence, intensity and mean monthly intensity of helminths in *T. abyssinicus* in Zaria 255

Appendix 19: Monthly prevalence, intensity and mean monthly intensity of ectoparasites on *S. vinacea* in Zaria 256

Appendix 20: Monthly prevalence, intensity and mean monthly intensity of helminths in *S. vinacea* in Zaria 257

Appendix 21: Meteorological data of rainfall, temperature and relative humidity collected from March 2002 to February 2004 in Zaria, Nigeria 258

Appendix 22: Pearson correlation coefficient for prevalence of ectoparasites and helminths with rainfall, temperature and relative humidity in Zaria, Nigeria 259

ABBREVIATIONS, DEFINITIONS, GLOSSARIES AND SYMBOLS

Abbreviation	**Meaning**
ABU	Ahmadu Bello University
ANOVA	Analysis of Varaince
BBWD	Black-billed wood Dove
bw	Body weight
ºC	Degrees centigrade
cm	Centimetre
CN	Coagulation Necrosis
Columbids	Members of the bird family Columbidae
CS	Cross Section
CV	Congested Central Vein
DDT	Dichloro-diphenyltrichloroethane
DMRT	Duncan's Multiple Range Test
DP	Domestic Pigeon
E	East
EEE	Eastern Equine Encepalomyelitis
e. g.	For example
et. al.	And others
→	Fatty degeneration or Renal tubular necrosis
g	Gram or Relative centrifugal force
G	Guage or necrosis of intestinal glands
GIT	Gastrointestinal tract
>	Greater than

H	Haemorrhage
Hb	Haemoglobin
H & E	Haematoxylin and Eosin Stain
IAR	Institute of Agricultural Research
IC	Inflammatory Cells
Kg	Kilogram
LD	Laughing Dove
<	Lesser than
LS	Longitudinal Section
m	Metre
M	Molar or necrosis of myocardial cells
MD	Mourning Dove
mg	Milligram
ml	Millilitres
mm	Millimetre
MMI	Mean monthly intensity
N	North
NFM	Norhern Fowl Mite
NNGS	Nigerian Northern Guinea Savanna
P	probability
%	Percentage
±	Plus or Minus
PCV	Packed Cell Volume
rbc	Red blood cell

S.E.	Standard Error
SP	Speckled Pigeon
Sp.	Species (singular)
Spp.	Species (plural)
TFM	Tropical Fowl Mite
V	Necrosis of intestinal villus
VD	Vinaceous Dove
Wks	Weeks

CHAPTER 1 INTRODUCTION

The Columbids (Doves and Pigeons) are members of the family Columbidae, order Columbiformes and class Aves. Elgood *et al.* (1994) identified 19 species of Columbids in Nigeria, 15 of which occur in the Nigerian Northern Guinea Savanna. The Columbidae is a large and successful family of birds. They are in many aspects of appearance and behaviour a homogenous family, with high reproductive rate, efficient escaping behaviour, hardiness and longevity. These attributes have contributed to the success of the Columbids than their production of crop milk (Elgood, 1977; Goodwin, 1983). They are arboreal, living in or nesting, roosting and taking cover in trees, and have also developed cliff and ground dwelling abilities and they are among the most vividly coloured birds in the world and others are clad in dull and cryptic plumage (Goodwin, 1983). Columbids are world wide in distribution with different representative species found in the various zoogeographical regions of the world, and they are considered as cosmopolitan because some species live in close proximity to human habitation. The first human impression about Columbids was that of a symbol of peace, love and fertility (Kligerman, 1978). Columbids are of economic importance and in some countries such as America, Belgium, Spain, Egypt and even Nigeria, they are bred for food and trained for sport, and numerous species are exhibited in zoological gardens throughout the world, and the number of pigeon breeders has increased considerably in recent years, particularly in the USA (Macrae, 1964). In Nigeria, Columbids have been hunted and eaten by man, and recently, the intensity has increased, moreso at “suya” spots (barbecue spots) in urban centres of northern Nigeria, especially in Zaria (Oniye *et al*., 2000a). This no doubt provides an indication of their present culinary and economic importance as hunted wildlife in Nigeria.

Columbids feed mainly on seeds, fruits or other food items small enough for them to swallow whole and also supplement their diet with insects, slugs and maggots, and other invertebrate materials such as snails and earthworms (Rowan, 1983; Adang, 1999). These diets that the pigeons consume have been implicated as sources of helminths of birds (Soulsby, 1982). For example, ants belonging to the orders Pheidole and Tetramorium were reported to serve as intermediate hosts in the transmission of *Raillietina* species (Bolton, 1973), while many larvae and adults of stored grain insect pests such as *Tenebrio* and *Tribolium* spp., are implicated as intermediate hosts of *Hymenolepis* spp. (Cheng, 1973). It is therefore safe to assume that the birds may acquire helminth infections from their diets particularly as the diet of birds according to Malhotra and Capoor (1980) has been known to a greater extent to determine their parasitic fauna. Whitney (1968) reported that helminths weaken Columbids, making long continued flying impossible and eventual death of such pigeons (Owen, 1972). This threatens the existence of these avian species by altering their normal development and consequently uncontrollable death. Nematodes migrate from the intestine to the liver, trachea and lungs and back to the intestine to develop (Michel, 1974). While in these tissues, the parasites do not only cause intestinal obstruction, they also cause severe haemorrhagic enteritis, and consequently reduced egg production (Michel, 1974). Domestication and intensive rearing of pigeons has increased awareness of clinical diseases and mortality from heavy infection with internal parasites (Schock and Cooper, 1978).

Parasites are part of the whole spectrum of issues facing wildlife managers, and are a part of the management puzzle as are food habits, population dynamics and habitat requirements. Parasites may thus be responsible for a number of serious health problems among pigeons, either directly or indirectly as vectors in the transmission of pathogens.

Pigeons and their nests are subject to ectoparasites many of which include lice, ticks, mites, louse-flies, fleas and bugs (Murton, 1965). Lice and mite infestations often cause stress and loss of condition (Schillhorn van veen and Mohammed, 1975).

Parasitic diseases may have particular deleterious or debilitating effects on affected birds, especially young pigeons (squabs) retarding growth and healthy development and may make older birds prone to secondary infections, lowering resistance to and complicating the course of other infections (Galloway, 1972).

In Nigeria, investigations on the parasites of Columbids are scanty compared with the large volumes of information available on the parasites of other birds such as chicken, guinea fowl, turkey and duck (Abdu *et al*., 2002). Available information on parasites of some Columbids in Nigeria include those on *C. l. domestica* (Dede and Richards, 1998; Audu *et al*., 2004; Ademola and Fagbohun, 2005; Atsineka and Banke, 2006), on *Streptopelia senegalensis* (Oniye *et al*., 2000a; Gadzama *et al*., 2005), on *Columba guinea* (Shotter, 1978; Dede and Richards, 1998) and on *Streptopelia decipiens* (Dede and Richards, 1998).

Several species of the Columbids are hunted or trapped by man to supplement protein sources or traded to augment income, and although Columbids are not endangered, over-hunting could pose a threat to them (Ezealor, 2005 per. com.). There has been the growing need in Nigeria to domesticate some wild animals for their meat (Ajayi, 1975). For instance, the Nigerian National Wild life Conservation Committee has recommended the domestication and breeding of some wild animals like the African giant rat and Quail to supplement meat protein available to the populace (Haruna *et al*., 1997). Some Columbids like Laughing Dove and Speckled Pigeon have the potentials for domestication, but their

successful domestication requires an extensive study of their diseases and pathologies in both wild and captive birds. This may also aid in the development of possible control measures, which may help in enhancing the survival of the birds and complement efforts towards public enlightenment.

Ascaridia galli is a common parasite of poultry (Ruff and Norton, 1997) and has been reported in pigeons and doves in Zaria (Abdullahi *et al*., 1992; Oniye *et al*., 2000a; Audu *et al.,* 2004; Gadzama *et al.,* 2005). Ascaridiasis is an intricate problem to poultry breeders and so it could be to pigeon breeders and fanciers. Available literature indicated meager information on the effect of *A. galli* in pigeons.

This study was therefore designed with the aim of examining Columbids in Zaria for ecto- and helminth parasites in order to determine the:

a) prevalence of different species of ectoparasites of Columbids in Zaria
b) prevalence of different species of helminths of Columbids in Zaria
c) body weights and Packed Cell Volume of infested / infected and uninfested / uninfected Columbids and
d) to evaluate the effect of *Ascaridia galli* in experimentally infected Domestic Pigeons (*C. l. domestica*).

CHAPTER 2 LITERATURE REVIEW

2.1 **The Family Columbidae**

Columbids are pigeons and doves, the word "pigeon" is of French origin and the word "dove" is of Anglo-Saxon origin (Levi, 1969), but pigeons and doves are synonymous. All domestic breeds of pigeons and all wild and feral populations are classified as *Columba livia* they have adapted to and thrive in a wide variety of habitats. The wild ancestor is considered to be the rock pigeon or rock dove of Europe, Asia and North Africa. Domestic forms of the rock pigeon occur in every country except at the polar caps. Feral birds probably occur in every sizeable town in the world with the possible exception of a few small islands. The only other species of Columbidae, which has been domesticated is the Barbary dove, a form of the African collared dove (*Streptopelia roseogrisea*) (Levi, 1969). The pair bond in domestic varieties and in ferals always last until death or removal of mate and both sexes take equal part in nest-building, incubation and care of young (Goodwin, 1983). Typically in wild, feral and domestic pigeons, sexual maturity is attained when first egg is produced at approximately 150 days and two eggs are usually laid. Life span in domestic birds can be as long as 15 years, but reproductive success declines after 5 years although egg-laying and semen production can continue up to 11 years (Levi, 1965). Incubation time for typical pigeons is 16-17 days, for the first 4-5 days of life, the young are fed 'crop milk', a substance unique to the Columbidae (Farner and King, 1973).

2.2 **Description of some Columbids**

a. *Columba livia domestica* (Domestic Pigeon)

Domestic Pigeon (DP) is highly variable urbanised, domesticated about 4,500 B. C. Their colour varies from blue-grey, pale cinnamon, and blackish to white (Plate I). Habitat

characteristics are bare rocky hills and buildings. It takes flight with clatter of wings, often flies low, over the ground. They usually fly in pairs, small parties or large flocks. It feeds on the ground in rock-strewn terrain and in fields, sometimes mixing with other pigeons and doves. The sexes are similar and they use ledges high on buildings, making nest in a corner or in the angle between horizontal and vertical stones. The clutch size is usually two and the eggs are white in colour (Goodwin, 1983).

b. *Streptopelia senegalensis* (Laughing Dove)

The Laughing Dove (LD) is a small sub-Saharan dove that has a black spotted reddish foreneck, which distinguishes it from all other doves. The head is vinous, the mantle brown, the rump dark-grey and the under parts are vinous becoming white on the belly (Plate II). The grey-blue wing coverts and the secondaries are conspicuous at rest and in flight. This species is semi-tamed and is numerous in villages and towns, spending much of its time on the ground feeding on fallen seeds (Elgood, 1960). The sexes are similar and the nest is a very flimsy platform of twigs, rootlets and tendrils, built in a small tree or building at a height of 1 to 5 m. The eggs are usually two in number and white in colour (Elgood, 1960).



Plate I: *Columba livia domestica* (Domestic Pigeon) showing field marks for identification
(Source: Adang, 1999)

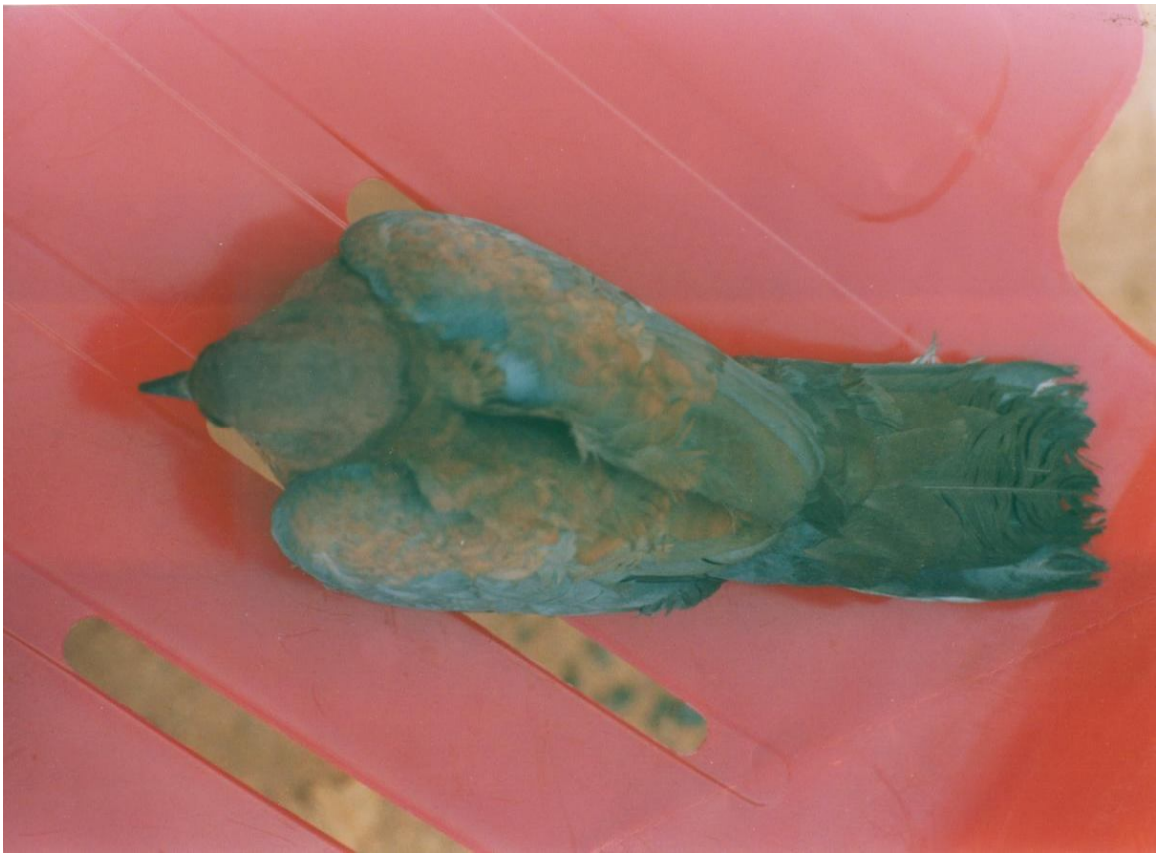


Plate II: *Streptopelia senegalensis* (Laughing Dove) showing field marks for identification
(Source: Adang, 1999)

c. *Streptopelia decipiens* (African mourning Dove)

The Mourning Dove (MD) is a dark-grey dove of green vegetation. The lower breast and belly are pale grey and the tail is tipped white and lacks the dark band. It has a black half collar at the base of the hind neck (Plate III). The quavering throaty chucking call uttered by both sexes is a guide to identification. It is fond of riverine fringing vegetation. The sexes are similar and the nest is a flimsy platform mainly of twigs built at a height of 2 to 14 m in a variety of trees. The eggs are usually white and the clutch size is two (Serle *et al*., 1992).

d. *Columba guinea* (Speckled Pigeon)

The Speckled Pigeon (SP) is a large robust pale grey pigeon of farmland and gardens. It is found on buildings and in trees and feeds on the ground (Elgood, 1960). It is much larger than the several *Streptopelian* species. The wing-coverts are conspicuously spotted with white and there is a large patch of bare red skin around the eyes (Plate IV). The bill is black and the legs are dark red (Serle *et al*., 1992). The back is chestnut and the rump is light grey and very conspicuous in flight. It has an advertising cooing call like that of the feral pigeon (Rowan, 1983). It is a savanna species that penetrates as far as 15 N° (Fry, 1965). The nest is a typical platform of twigs and rootlets built in a tree or in building usually with two white eggs. The sexes are similar and often gregarious when not breeding.



Plate III: *Streptopelia decipiens* (Mourning Dove) showing field marks for identification
(Source: Adang, 1999)



Plate IV: *Columba guinea* (Speckled Pigeon) showing field marks for identification
(Source: Adang, 1999)

e. *Turtur abyssinicus* (Black-billed wood Dove)

The Black-billed Wood Dove has a black bill. The top of the head is blue-grey becoming whitish on the fore head (Plate V). The upper parts of the body are some what grayer brown, under parts slightly paler and pinker, white on belly (Serle *et al*., 1992). It flies singly or in pairs in dry savanna woodland, open scrub, cultivated land, thickets and secondary growth. The birds congregate in flocks at water holes in dry areas. They nest and roost in trees in thickets, the sexes are similar, the eggs are usually two in number and white in colour (Serle *et al*., 1992).

f. *Streptopelia vinacea* (Vinaceous Dove)

The Vinaceous Dove (VD) is a small, whitish grey or pale pinkish dove with light brown back and wings, dark flight feathers, the tail with black base and largely white at the sides. It has a black hind neck collar, black bill, dark brown eyes that lack the red orbital ring and dull purple red legs (Plate VI). The bird inhabits dry woodland and bushy grassland as well as cultivated land, foraging on open ground and roost in trees. They fly singly, in pairs or flocks in a variety of savanna habitats. They nest and roost in trees in thickets, the sexes are similar and the eggs are usually two in number and white in colour (Serle *et al*., 1992).



Plate V: *Turtur abyssinicus* (Black-billed wood Dove) showing field marks for identification (Source: Adang, 1999)



Plate VI: *Streptopelia vinacea* (Vinaceous Dove) showing field marks for identification
(Source: Adang, 1999)

2.3 **Parasites of Columbids**

2.3.1 *Ectoparasites*

Most of the ectoparasites of pigeons are members of the phylum Arthropoda. Pigeons and their nests are subject to a range of ectoparasites, which include lice, mites, ticks, bugs, fleas and flies (Petrak, 1969).

Lice: Lice are common external parasites of birds and are confined to the suborder Mallophaga, the chewing lice. Mallophagans are very host-specific, but birds may harbour several species at the same time (Emerson, 1956). Bush and Clayton (2006), evaluated the role of body size in host specificity using reciprocal transfer experiments with feather lice, and realized that most parasites show at least some degree of host specificity. Many different groups of host-specific parasites show a striking correlation between parasite and body size, suggesting that body size reinforces specificity and host switching is most likely between hosts of similar body size.

Clay (1957) stated that the species distribution of bird lice generally coincides with the distribution of their hosts. Lice from the super class Ischnocera are generally feather feeders only and feed in sharply defined areas while lice from the super class Amblycera take blood and serum in addition to feathers (Soulsby, 1982).

Lice are transferred from one bird species to another if their hosts are in close contact. Intraspecific transmission of bird lice is done mainly during host mating, breeding of the young, roosting of gregarious species, and using common dusting baths (Cheng, 1973). Pigeon lice are frequently found on domestic fowl if the pigeons nest above or close to the

fowl or their pen (Soulsby, 1982). The slender pigeon louse (*Columbicola columbae*) is known to transfer between hosts by transmission with the hippoboscid pigeon fly (*Pseudolynchia canariensis*) (Kiernans, 1975).

Lice undergo simple (incomplete) metamorphosis and the total life cycle is about 30 to 36 days (4-5wks) and is spent on the host. One pair of lice may produce 120,000 descendants within a few months (Hofstad *et al*., 1984).

Lice infestation causes local dermatitis, intense irritation resulting in discomfort, inability to eat, leading to poor growth and production, anaemia, emaciation and death (George *et al.*, 1992; Zaria *et al*., 1996). Some of the parasites can also act as vectors and transmit various diseases to their host (Fabiyi, 1972a; 1980). Sick birds tend to be more heavily infested with lice than healthy birds. Gless and Raun (1959) revealed that an average of 23,000 body lice per bird (chicken) reduced egg production by 15%. De Vaney (1976, 1979) showed that decrease egg production, hen weight, clutch size and feed consumption correlated with populations of lice.

Factors of grooming and relative humidity may be important in determining variations in densities of body lice on birds. In nature, the size of the population of lice on a host is variable and may seem to be seasonal Keymer *et al.* (1962). In a survey of wild birds in Britain, Keymer *et al.* (1962) found that of the 2, 044 birds examined, only 9 carried a parasite burden that could be considered pathogenic.

Diagnosis of lice is established by discovery of eggs, nymphs or adults on the feathers. Some species of lice have a predilection for certain sites to which they are mainly confined, hence the common names of head, wing, body, feather or shaft lice. Lice on pigeons can be controlled by using the same methods and materials, that are used on commercial poultry (Hofstad *et al*., 1984).

Several lice species have been reported on pigeons and doves. *Columbicola columbae*, an ectoparasite of pigeons and doves is very common. Its preferred site is the anterior part of the body, where it may cause a mild pruritus, and is common with most pediculosis in Columbids, but heavy infestations are usually seen only in diseased and debilitated birds (Petryszak *et al*., 2000). Arends *et al.* (1984) reported *Menopon gallinae* (shaft louse), *Campanulotes bidentatus compar* (small pigeon louse) and *Columbicola columbae* (slender pigeon louse) as pigeon lice. Nelson and Murray (1971) reported *C. columbae* on *Columba livia*. Pilgrim (1976) found *C. columbae* as the most common and most abundant ectoparasites in *Columba livia* in New Zealand. Yavornitskii and Kharambura (1982) recovered *C. columbae* on *Columba livia* and *Streptopelia decaocto*. Soulsby (1982) reported *Goniocotes gallinae* (fluff louse), *Menopon gallinae*, *Columbicola columbae* and *Goniodes minor* to occur on domestic and wild pigeons. Cheng (1973) reported *C. columbae*, *Lipeurus bidentatus, Lipeurus damicornis*, *Goniocotes bidentatus* and *Goniodes minor* to occur on pigeons. Davis *et al.* (1971) listed the following genera of lice as common to the order Columbiformes*; Colpocephalum, Hohrstiella, Neomenopon, Auricotes, Campanulotes, Coloceras, Columbicola, Kodocephalon, Physconelloides and Syrrhapteous.*

Foronda *et al*. (2004) in a study of the prevalence and intensity of the parasites of 50 wild doves (*C. livia*) from the city of Santa Cruz de Tenerife in the Island of Tenerife (Canary Archipelago), found *C. columbae* (100.0% prevalence, 111.4 ± 76.8 mean intensity) and *Campanulotes bidentatus* (94% prevalence, 48.4 ± 26.6 mean intensity) as lice on apparently healthy doves.

Dovc *et al*. (2004) in an epidemiological research on the health status of free-living pigeons in the city of Ljubljana, Slovenia reported *C. columbae* and *Campanulotes bidentatus compar* as ectoparasites. Mushi *et al*. (2000) found *C. columbae* (30%) in apparently healthy pigeons in a study of parasites of domestic pigeons in Sebele, Garborone, Botswana.

Conti and Forrester (1981) compared the parasites of indigenous populations of Mourning doves (*Zenaida macroura*) in north and south Florida with those of an introduced population of white-wing doves (*Zenaida asistica*) in south Florida and reported seven Mallophagans (lice spcies) as ectoparasites of these doves.

Rosciszewska *et al*. ((1996) investigated the infestation of *C. l. domestica* by Mallophaga in both breeding and feral pigeons in Cracow. Five species of Mallophaga were distinguished: *C. columbae*, *Campanulotes bidentatus compar*, *Coloceras damicornis fahrenholzi*, *Hohorstiella gigantean* and *Neocolpocephalum turbinatum*. *C. columbae* and *C. b. compar* showed the highest intensity of occurrence. The most frequent was the mixed infestation of these two species. The results showed more infestation of the breeding pigeons, and the

females were more intensively infested than the males, the higher degree of infestation occurred in old and weak pigeons.

Petryszak *et al*. (2000) analysed the population structures of Mallophaga infesting urban pigeons in Cracow. They examined 70 pigeons, in which *C. columbae* and *C. b. compar* were the dominant species. Forty-seven per cent of the birds infested had less than 100 specimens of Mallophaga, although the highest infested bird had up to 900 specimens. Sex and age of bird did not influence the number of lice present and only poor health condition of individuals allowed higher infestation. The sex structure of the parasites was balanced with slightly higher number of females. The highest number of lice was detected in autumn and larvae were predominant. A similar tendency was observed in *C. columbae* population. *C. b. compar* showed highest prevalence in July and the imago stage dominated this species.

Senlik *et al*. (2005) examined 100 *C. l. domestica* in Bursa Province of Turkey for ectoparaites and found that 72.0% of them infested by three ectoparasites (lice), *Goniocotes bidentatus* (47.0%), *C. columbae* (44.0%) and *Menopon gallinae* (1.0%). Although a higher infestation rate was found in adults (75.3%) compared to young pigeons (64.5%), there was no significant difference between the groups. There was also no significant difference in the infestation rates between the males (73.3%) and females (70.9%). The highest infestation rate was observed during the summer months (84.0%) while the lowest was observed during the spring months (48.0%).

Mites: The common free-living ectoparasitic mites of birds belong to the family *Dermanyssidae* and these include the chicken mite, northern fowl mite and tropical fowl

mite (Loomis, 1984). Mites of many species occur in pigeons but only a few are pathogenic (Keymer, 1969). The pigeon feather mite *Falculifer rostralis* and the depluming mite *Cnemidocoptes mutans* occasionally damage the plumage and can be difficult to eradicate (Petrak, 1969). All mites of the family *Dermanyssidae*, Genus *Dermanyssus* are nidicolous, emerging from the shelter of the nest material or adjacent sites for brief periods of attachment to the host where they engorge with blood. The chicken mite, *Dermanyssus gallinae* also known as the red mite, roost mite or poultry mite has been reported on pigeons (Keymer, 1969; Petrak, 1969; Cheng, 1973; Soulsby, 1982; Arends *et al*., 1984; Loomis, 1984; Yavornitskii and Kharambura, 1982; Foronda *et al*., 2004). *Dermanyssus gallinae* is practically world wide in distribution and a common parasite of chicken and other domestic and wild birds, and occasionally man. The life cycle may be completed in as little as 7 days (Petrak, 1969; Arends *et al*., 1984). The mite spends much of its life cycle away from its host, the adult and nymph only visiting birds to feed mainly at night. Infestation leads to restlessness of the birds at night caused by much irritation. In heavy infestation, anaemia usually occurs due to loss of blood. De Vaney *et al*. (1977) reported the following effects on birds as a result of mite infestation; low egg production, decreased weight, decreased volume of seminal fluid, decreased red blood cell counts and packed cell volume as well as low mean haemoglobin concentration. Human beings may also be attacked, through invasion of human dwellings by mites from outdoor pigeon nests, causing itching and dermatitis (Soulsby, 1982).

Dermanyssus gallinae serves as the vector of *Borrelia anserina*, the cause of avian spirochaetosis and also transmits *Lankesterella garnhamei* infection (Laison, 1960). The virus of Eastern Equine Encephalomyelitis (EEE) has been isolated from this mite (Howitt *et al*., 1948).

The discovery of nymphs or adults in the plumage or in the nests is evidence of infestation. Both the nymphs and adults are nocturnal feeders and leave the hosts after a blood meal (Soulsby, 1982). Birds can be treated with any of the registered ascaricides such as pyrethrum or carbaryl (Hofstad *et al.*, 1984).

The northern fowl mite (NFM) (*Ornithonyssus sylviarum*) is the commonest and most important permanent parasite of poultry in the United States of America, England and New Zealand, which has also been reported in many species of birds including pigeons (Soulsby, 1982; Arends *et al*., 1984). The NFM can be seen on birds in the day and night, and its life cycle is completed in less than one week on the bird. Eggs are laid on the feathers and are hatched in one day. The mites can be found on birds or in their nests and they feed intermittently on the birds. They can also bite through the human skin and thus cause pruritus. Heavily infested birds may suffer irritation, lost of weight, reduction of egg production and when the loss of blood is great death may result (De Vaney, 1979; Soulsby, 1982; Loomis, 1984). Soulsby (1982) reported that the mite might transmit fowl pox and the viruses of St. Louis encephalitis and western equine encephalomyelitis.

Dust of carbaryl or organophosphorus preparations may be applied to birds and their nests for prevention, control and treatment (Harrison, 1961).

The tropical fowl mite (TFM) (*Ormithonyssus bursa*) is distributed through out the warmer regions of the world. Its hosts include poultry, pigeons and even humans.

This mite can pass its entire life cycle on the bird and its biology, habits and control are similar to those of NFM although a greater proportion of the eggs are laid in the nest (Baker *et al*., 1956).

Other mite species reported on pigeons by Arends *et al*. (1984) are *Haemolaelaps casalis*, *Falculifer cornutus*, *Megninia columbae*, (feather mites); *Knemidocoptes gallinae* (depluming mite); *Laminosioptes cysticola* (cyst mite); *Cytodites nudus* (air sac mite); *Neonyssus columbae*, *Neonyssus melloi* and *Speleognathus striatus* (nasal mites) and *Syringophilus columbae* (quill mite). Keymer (1969) reported *Falculifer rostratus* and *Knemidocoptes mutans* to occur on wild pigeons. Foronda *et al*. (2004) reported *D. gallinae* (6% prevalence; 241.0 ± 138.9 mean intensity) and *Tinanminyssus melloi* (100.0% prevalence; 218.3 ± 117.3 mean intensity) on pigeons from then city of Santa Cruz de Tenerife. Conti and Forrester (1981) reported seven acarines in Mourning doves (*Zenaida macroura*) and White-wing doves (*Zenaida asiatica*) in north and south Florida.

Ticks: Ticks infesting birds (pigeons) belong to the family Argasidae (soft-bodied ticks or fowl ticks). They have no scutum (dorsal shield) and except for the larvae, feed intermittently in all stages. Reduced productivity is associated with anaemia, but also possibly due to tick-produced toxic substances (Petrak, 1969). Ticks transmit such diseases as avian spirochaetosis, tularemia, piroplasmosis, anaplasmosis, difilariasis, certain rickettsial and many viral diseases, including encephalitis (Goethe and Kunze, 1973).

The complete life cycle of fowl ticks takes about 7-8 weeks during warm weather and longer during cold seasons. Adult ticks remain inactive in cracks and crevices during cold weather and adults may live without a blood meal for more than four years (Arends *et al*., 1984).

Birds suffer chiefly from attacks of these ticks during the warm dry season. Loss of blood may reach proportions of a fatal anaemia, at least, there may be emaciation, weakness, slow growth and lowered production. Ruffled feathers, poor appetite and diarrhoea are signs suggesting tick infestation (Reid, 1956). Control requires treatment of premises and nests using approved ascaricides (Soulsby, 1982).

Argas persicus, the fowl tick, is the most common tick on pigeons (Petrak, 1969; Soulsby, 1982; Arends *et al*., 1984). Rothschild and Clay (1952) reported *Argus reflexus* as the best-known tick of pigeon in Great Britain. According to Khoury and Maroli (2004), pigeons can be infested by several ectoparasites among these is *A. reflexus* the well known pigeon tick. It is the most important ectoparasite that can involve human health. Buildings infested by *A. reflexus* and attacks by this tick to man are frequently reported, with an increasing concern for human health. Infact, the tick bite can include anaphylactic reactions for the presence of allergens and as vector, the tick can transmit some pathogens. *Argas reflexus* occurs chiefly on pigeons and has been found in Europe, Asia, Russia and Algeria and may transmit *Borrelia anserina* to poultry (Hoogstraal and Khols, 1960). *Argas reflexus hermanni* is the pigeon tick of Africa while *Argas reflexus neghmei* is a pest of both chickens and pigeons in Chile and is known to bite children in homes adjacent to poultry houses (Petrak, 1969). *Argas reflexus hermanni* in Egypt is suspected of transmitting West Nile and Chenuda virus and the Quaranfil virus group among pigeons and is implicated in the transmission of Q fever rickettsia (Petrak, 1969). Siuda *et al*. (1979) reported the occurrence of *Argas argas polonicus* on *Columba livia* in Poland. Nosek *et al*. (1980) also reported *Argas persicus* to occur on pigeons in warm areas in Czechoslovakia while

Hoogstraal *et al*. (1977) reported the occurrence of *Argas africolumbae* in the nest of Cape Rock pigeon and Speckled Pigeon.

Bugs: The family *Cimicidae* in the order Hemiptera includes several blood-sucking bugs of birds. These insects have mouthparts adapted for piercing the skin and sucking body fluid. They are flattened dorsoventrally and adults measure 2 to 5 mm long x 1.5 to 3 mm wide. The colour varies according to species from brown to yellow or red. Bites from attack by a large number of bugs are usually followed by swellings and itching, caused by injection of saliva into the wounds. This large number of bugs may lead to anaemia, decreased egg production, increased feed consumption and lower peak egg production.

The most widespread of these bugs is the common bedbug (*Cimex lectularis*), which attack pigeons, poultry, humans and other mammals (Arends *et al*., 1984). A closely related species *Cimex columbarius* is found on pigeons in Europe. Rothschild and Clay (1952) stated that few wild birds are attacked by bugs because the bugs can survive only if the host is the type that returns to its old nest, and the nest must be in a situation where it will remain fairly dry. *Triatoma sanguisuga* (a bug species) was found to harbour the virus of Eastern Equine Encephalomyelitis in Kansas, with naturally occurring viral infections found in pigeons (Arends *et al*., 1984).

Treatment should be directed against day-time hiding places of the bugs in cracks and crevices. Spraying the birds with pyrethrum will also be helpful if an infestation is high (Petrak, 1969).

Fleas: Fleas (Order Siphonaptera) are small brownish or black insects with laterally compressed bodies enabling them to run rapidly through the feathers. The adults although

devoid of wings, have well-developed legs and are able to leap considerable distances as well as run. The mouthparts are especially adapted for piercing the skin of their host and for sucking blood from various host species. They are cosmopolitan in distribution, although more abundant in temperate and warm climates (Petrak, 1969).

The sticktight flea (*Echidnophaga gallinacea*) has been reported from pigeons among other host species (Arends *et al*., 1984). This flea causes irritation and blood loss especially in young birds and infested birds may be seriously damaged leading to death. Egg production is lowered in older birds. The European chicken flea (*Ceratophyllus gallinae*) has also been reported in pigeons (Arends *et al*., 1984). This flea stays on birds only long enough to feed, while its immature stages occur in nests and other surroundings.

The most important control measures for fleas are removal of infested litter and thorough spraying to kill immature fleas. In Scotland, tests have shown control of *C. gallinae* by using the pyrethroid permethrin as a 0.125-0.25% spray to nest boxes and litter (Tritchner, 1983).

Domestic animals such as poultry, dogs and cats should be kept away from infested birds, as they are potential sources of re-infestation (Arends *et al*., 1984).

Flies: The pigeon fly, *Pseudolynchia canariensis*, is an important parasite of domesticated pigeons in warm or tropical areas (Soulsby, 1982). It has been known since 1896 in the southern half of the United States of America and also occurs in many other countries. The pigeon fly is a member of the Hippoboscidae or louse flies. The body is dorsoventrally flattened, and the head is provided with a short stout beak. It is dark brown, 6 mm long and

resembles the sheep ked, but has a pair of transparent, tapering wings with the venation reduced and concentrated along the anterior border. The claws are strong and spurred. The life cycle of pigeon fly is unusual in that the larvae matures inside the female and pupates immediately upon being ejected. The pupal stage requires about 30 days, adults live for about 45 days and deposit four or five young ones (Benbrook, 1965).

These pigeon flies move rapidly through the feathers and suck blood, particularly from nesting pigeons 2-3 weeks of age (George and Abdu, 1989). They may also bite humans, inflicting a painful skin wound that persists for several days (Soulsby, 1982). Infested pigeons suffer from blood loss and irritation. The fly may also transmit a protozoan blood-cell parasite (*Haemoproteus columbae*) the cause of a malaria-like disease of pigeons (Lapage 1961; Kemp, 1978). George and Abdu (1989) in a case report of pigeon fly, malaria and pox in Domestic Pigeon in Zaria, observed a large number of bacteria (*Staphylococci* sp. and *Streptococci* sp.) from the haemolymph smears of the pigeon fly. They also reported bodies morphologically similar to sporozoites of infested flies. They also suggested some form of association between the pigeon fly and the tranmission of pox-virus. Orajaka and Ezeokonkwo (1977) reported the occurrence of *P. canariensis* from chicken in Nigeria.

The organophosphorus compounds may be of value in treatment and control of pigeon flies. Manual removal of the flies and periodic inspection in case the birds become re-infested are also important control measures. Foronda *et al*. (2004) reported *P. canariensis* (36.0% prevalence; 6.2 ± 1.6 mean intensity) in the city of Santa Cruz de Tenerife. Mushi

et al. (2000) reported *P. canariensis* from Sebele, Garborone, Botswana while Conti and Forrester (1981) reported two dipterans (possibly *P. canariensis*) on Mourning and White-wing doves in north and south Florida. In Nigeria, several works (Abdu *et al*., 2002) have been done on the ectoparasites of local and exotic poultry as compared to very little on wild and domestic pigeons.

2.3.2 *Helminths*

There are many species of helminths that infect Columbids and these can vary considerably in their size and shape. The food habit of Columbids and the life cycle of the parasites determine the variety of the infections Columbids can acquire (Cheng, 1973). Columbids are free-range and thus acquire infections with a wide range of parasites having direct or indirect life cycles because of their increased exposure to larger areas of land and various intermediate hosts and the eggs of parasites (Fabiyi, 1972a, b).

Trematodes: Trematodes differ from cestodes (class: cestoda) in being unsegmented and having a digestive system. The life cycle of all trematodes parasitizing birds requires a molluscan as an intermediate host and some species also use a second intermediate host (Hofstad *et al*., 1984). Over twenty species of flukes are said to occur in birds, and the oviduct flukes *Prosthogonimus macrorchis* and *P. ovatus* appear to be the most frequent parasite of many wild birds (Soulsby, 1982).

Angus (1978) reported the following trematodes in the small intestine of pigeons: *Echinostoma revolutum*, with snails, tadpoles and frogs as intermediate hosts, *Echinoparyphium recurvatum*, with fish, tadpoles and snails as intermediate hosts,

Cotylurus cornutus and *C. flabelliforms* with snails as intermediate host. Barrows *et al*. (1977) reported *Echinostoma revolutum* in Mourning Doves (*Zenaida macroura*) in south east United States of America. Bean *et al*. (2005) identified two trematodes while examining 63 Eurasian collared-doves (*Streptopelia decaocto*) from Florida for parasitic helminths. *Tanaisia bragai* had mean intensity of 13.5.

Glass *et al*. (2002) reported a prevalence of 7.0% for trematodes while examining the helminth communities of 171 fledged white- wing doves (*Zenaida asiatica asiatica*) from an expanding eastern population in Texas, USA. Conti and Forrester (1981) found two trematodes in Mourning doves (*Zenaida macroura*) and white-wing doves (*Zenaida asistica*) in north and south Florida.

Prosthogonimus sp. "the oviduct fluke" has caused economic losses to poultry by drastically reducing egg production and occasionally being enveloped within a hen's egg. The adults of *Tanaisia bragai* are often found in the collecting tubules of the excretory system of pigeons, turkeys and chickens (Kingstone, 1984). *Echinoparyphium paraulum* has been reported from pigeons, occurring in the rectum and cloaca and causing blood-tinged faeces.

Cestodes: Cestodes are found more frequently in warmer seasons, when intermediate hosts are abundant (Soulsby, 1982). Birds become infected by eating the intermediate hosts which are crustaceans, earthworms, slugs, snails or leeches, thus allowing the larval stages of the tapeworms (cysticercoids) access to the intestine. Important cestodes of Columbids include duodenal cestodes: *Amoebotaenia cuneata*, *Hymenolepis cantaniana*, and *H.*

carioca; and *Raillietina cesticillus*, *R. tetragona* and *R. echinobothrida* from the small intestine (Soulsby, 1982; Ruprah *et al*., 1986). Barrows *et al*. (1977) reported two cestodes *Sarcocystis* sp. and *Hymenolepis* sp., from Mourning Doves (*Zenaida macroura*) in the United States of America. Bean *et al*. (2005) examined 63 Eurasian collared-doves (*Streptopelia decaocto*) from Florida for helminths. Nine species of helminths were identified, two of which were cestodes. Foronda *et al*. (2004) studied the prevalence and intensity of the parasites of 50 wild doves (*C. livia*) from the city of Santa Cruz de Tenerife in the Island of Tenerife (Canary Archipelago) and identified *Raillietina miracanth* with 44.0% prevalence and 12.3 ± 9.4 mean intensity. Glass *et al*. (2002) reported 17.0% prevalence for cestodes while examining the helminth communities of 171 fledged white-wing doves (*Zenaida asiatica asiatica*) from an expanding eastern population in Texas, USA. Senlik *et al*. (2005) necropsied and examined a total of 100 pigeons of which only 1.0% had *Raillietina echinobothrida*. Mushi *et al*. (2000) examined 12 adult pigeons from Sebele, Garborone, Botswana for the presence of helminths and recovered the cestode genus *Raillietina* sp. Most pigeons (80.0%) were infected with *Raillietina* spp. often in association with *Ascaridia columbae*. Conti and Forrester (1981) reported two cestode species while comparing the parasites of indigenous populations of Mourning doves (*Zenaida macroura*) in north and south Florida, USA, with those of an introduced population of white-wing doves (*Zenaida asistica*) in south Florida. Olsen and Braun (1980) examined 609 Band-tailed pigeons (*Columba fasciata fasciata*) collected in Colorado, and reported on two species of cestodes, *Hymenolepis annata* and *Raillietina* sp.

In Nigeria, Atsineka and Banke (2006) in a study of gastro-intestinal helminths of domestic pigeons in Makurdi Metropolis in Benue State, Nigeria, reported on an overall prevalence of 43 (86%) out of 50 pigeons examined. Six helminth species were identified, one cestode,

which was *R. cesticillus* (68%) and five nematodes. Twenty-three (92.0%) males were infected as against 20 (80.0%) females. A total of 27 (54%) had mixed infections while 16 (46.0%) had single infections. They suggested that poor hygienic and sanitary conditions within the metropolis could be linked to the high prevalence of helminths in domestic pigeons and thus recommended measures that could be taken towards the reduction of infection by parasites so as to provide good and hygienic pigeons for human consumption.

Dede and Richards (1998) reported on a prevalence of 66.7% of helminths in some Columbids in the North-east Zone of Nigeria. Out of 30 pigeons examined, comprising of 24 *C. l. domestica*, 4 *Columba guinea*, and 2 *Streptopelia decipiens*, 20 (66.7%) were infected by helminths. These comprised of 15 (62.5%) *C. l. domestica*, 3 (75.0%) *Columba guinea* and 2 (100.0%) *Streptopelia decipiens*. The helminths recovered were all cestodes and prominent among the cestodes was *Raillietina* spp. The species of *Raillietina* recovered include *R. joyeuxi*, *R. columbiella* and *R. cesticillus*. Other cestodes recovered were *Cotugnia cuneata*, *Retinometra serrata* and an unidentified one. *R. columbiella* was found in 13 (43.3%) with a range of 1-15 parasites per bird and mean intensity of 5.5 ± 4.8, *R. joyeuxi* was recorded in 12 (40.0%) birds with a range of 2-26 parasites per bird and mean intensity of 6.9 ± 6.0. *Raillietina cesticillus* and *C. cuneata* were found in 4 (13.3%) birds with a range of 1-6 parasites per bird and mean intensities of 2.6 ± 2.2 and 2.3 ± 1.5 respectively. *Retinometra serrata* was found in 2 (6.7%) birds with a range of 5-6 parasites per bird and mean intensity of 5.5 ± 6.7 while the unidentified cestodes was found in 2 (6.7%) birds with a range of 3-5 parasites per bird and mean density of 4.0 ± 1.4. All the cestodes were collected exclusively from the small intestine and were mainly restricted to the duodenal loop and the ileum. *Raillietina* spp. were dominantly encountered, occurring

in 16 (80.0%) of all the birds examined with *R. columbiella* prominent among them and cutting across all the species of pigeons examined. With the exception of an unidentified cestode, which was found strictly in *C. l. domestica*, all the other cestodes occurred in both *C. l. domestica* and *C. guinea*. The study showed single infection as the highest, occurring in 9 birds (30.0%), followed by double infections in 8 (26.7%) while triple infections were found only in 3 (10.0%) birds.

Oniye *et al*. (2000a) reported on a prevalence of 69.2% for helminths in 130 Laughing Doves (*Streptopelia senegalensis*) in Zaria. The helminths encountered included four species of cestodes all found in the intestine of the birds. The specific prevalences of the cestode infections in the birds were *Raillietina echinobothrida* 54 (41.5%), *R. tetragona* 6 (4.6%), *Hymenolepis carioca* 26 (20.0%) and *Amoebotaenia cuneata* 2 (1.5%). A total of 256 worms were recovered and this comprised of *R. echinobothrida* 166 (64.4%), *R. tetragona* 10 (3.9%), *Hymenolepis carioca* 72 (27.9%) and *A. cuneata* 8 (3.1%). The survey showed that *S. senegalensis* was infected more with cestodes.

Audu *et al*. (2004) carried out a survey for helminths of Domestic Pigeons (*Columba livia domestica*) in Zaria during the raining season between May and August, 2002. Out of the 60 pigeons examined, 26 (43.4%) were infected by helminths. Three species of cestodes were identified. The cestodes were: *R. tetragona*, *R. cesticillus* and *R. echinobothrida*. *Raillietina echinobothrida* was the most prevalent cestodes occurring in 15 (25.0%) birds, followed by *R. tetragona*, and *R. cesticillus* in 12 (20.0%) birds each. Sex-specific rate for the helminths was 15 (25.0%) in females and 11 (18.3%) in males. Chi square analysis showed a statiscally significant association between sex and infection ($P < 0.05$). Double

infection was the highest in the study and occurred in 13 (21.7%) birds, followed by single infection in 10 (16.7%) birds, while triple infection was found in 3 (5.0%) birds. All the helminths encountered were found in the intestine of the birds, but the duodenum had a higher number of parasites than the ileum. The study showed that *C. l. domestica* is moderately parasitised by helminths.

Gadzama *et al*. (2005) recorded a prevalence of 11 (44.0%) out of 25 *S. senegalensis* examined in Zaria for helminths. Three species of cestodes were identified which included *R. tetragona* occurring in 7 (28.0%) birds, *R. echinobothrida* in 2 (8.0%) birds and *Hymenolepis carioca* in 1 (4.0%) bird. The helminths showed predilection for the small intestine. The study showed that *S. senegalensis* could be a probable reservoir host of helminths especially cestodes.

Most cestode species cause little damage to their hosts and are considered harmless or less pathogenic (Ruprah *et al*., 1986). *Raillientina echinobothrida* commonly called "nodular tapeworm" is the most pathogenic and nodules, which are visible from the peritoneal surface, may be formed at the site of attachment and hyperplastic enteritis can occur (Raprah *et al*., 1986).

Nematodes: Nematodes constitute the most important group of helminths of Columbids. In the number of species and the amount of damage caused, they far exceed the cestodes and trematodes. Avian nematodes often have a broad host range and accordingly, nematodes found in Columbids may constitute a hazard for commercially raised birds (Soulsby, 1982). Nematodes also known as round worms, are most usually elongated, cylindrical and

unsegmented worms, usually spindle shaped with the anterior or posterior ends attenuated. Nematodes of importance in Columbids include *Syngamus trachea* found in the trachea, *Dispharynx nasuta*, *Tetrameres americana*, *T. fissipina*, *Microtetrameres helix* that infect the proventriculus, *Amidostomum anseris*, *A. skrjabini*, *A. raillieti* and *Epomidiostomum uncinatum* are found in the gizzard, intestinal nematodes such as *Capillaria obsignata C. columbae*, *Ascaridia columbae*, *Ornithostrongylus quadriradiatus* are specific to the intestine, *Subulura brumpti*, *Trichostrongylus tenuis* and *Heterakis gallinarum* are found in the caecum (Soulsby, 1982).

Barrows *et al*. (1977) examined Mourning Doves (*Zenaida macroura*) for endoparasites in south east United States and found four nematodes, *Aproctella stoddardi, A. columbae* and *Dispharynx nasuta* included *n*ew host records. Bean *et al*. (2005) examined 63 Eurasian collared-doves (*Streptopelia decaocto*) from Florida for helminths and reported five species of nematodes, these included *A. columbae* (73.0%), *Fuhrmannetta crassula* (28.6%), *Ornithostrongylus quadriradiatus* (12.7%) and *Baruscapillaria obsignata* (11.1%). Foronda *et al*. (2004) reported four nematode species in 50 wild doves (*C. livia*) from the city of Santa Cruz de Tenerife in the Island of Tenerife (Canary Archipelago). These were *Tetrameres fissispina* (4.0% prevalence and 99.5 ± 34.1 mean intensity), *Dispharynx spiralis* (8.0% prevalence and 46.8 ± 11.6 mean intensity), *A. columbae* (40.0% prevalence and 8.4 ± 8.8 mean intensity and *Aonchotheca* sp. (18.0% prevalence and 6.0 ± 3.1 mean intensity). Glass *et al*. (2002) examined the helminths of 171 fledged white-wing doves (*Zenaida asiatica asiatica*) in Texas USA. Eleven helminth species were found with a total of 435 worms collected. Nematodes dominated numerically, accounting for 76.0% of the total worms collected. The helminths occurred mostly in the small intestine. Triple

infection (three helminth species per host) was found in three birds while double infection (two helminth species per host) occurred in 13 birds. Single infection (one helminth species per host) occurred in 70 birds while 85 birds had no infection. *Ascaridia columbae* occurred in 26.0% of the doves examined and accounted for 65.0% of all the worms collected. Prevalence and abundance of *A. columbae* varied with geographic region and host age but not with host sex. Their results suggested that the doves' sympatry with other Columbids and granivorous diet might be more important in shaping helminth community structure than the influences often associated with geographic range expansion. Conti and Forrester (1981) found seven nematode species in Mourning doves (*Zenaida macroura*) and white-wing doves (*Zenaida asistica*) in north and south Florida, USA. Nematodes were the most common parasites in all three populations. Infected doves contained one or two nematode species per dove. Total helminth burden per infected dove averaged 13.1 for white-wing dove, 19.9 for mourning doves in south Florida and 6.6 for mourning doves in north Florida.

Olsen and Braun (1980) examined 609 Band-tailed pigeons (*Columba fasciata fasciata*) in Colorado and identified four nematodes, which were *Ascaridia columbae*, *Splendidofilaria columbensis*, *S. hibleri* and *Chandlerella* robinson. Of the 609 pigeons examined, 76 (12.5%) harboured helminths.

Jackoski and Plank (1969) found that of the 56 pigeons trapped during the months of July and August, 1960 in Chicago, USA, 17.5% harboured helminths, 1.78% harboured *Ascaridia* sp. occurring in the small intestine and 5.34% harboured *Capillaria* sp. Wehr (1963) also reported *Ornithostrongylus quadriradiaitus* as a common parasite of

C. l. domestica and Eastern mourning Dove (*Zenaida macroura*) in North America.

Senlik *et al*. (2005) carried out a one-year study from April 2002 to March 2003 to determine the occurrence of helminth species and to evaluate the effect of host age, sex and season on prevalence and intensity. A total of 100 domestic pigeons (31 young and 69 adults) were necropsied and examined. Seventy-four pigeons had helminths. Two nematode species were identified, *Baruscapillaria obsignata* (63.0%) and *A*. *columbae* (42.0%). There were significant differences between the prevalence rates of *A*. *columbae* and *B*. *obsignata* by host age and sex. Significantly, the highest prevalence rate of *A*. *columbae* was observed in the autumn months, but there was no significant difference in the seasonal prevalence of *B*aruscapillaria *obsignata*. The mean intensities of *Baruscapillaria obsignata* and *A*. *columbae* were higher in adults than in young but did not differ significantly between the two sexes. The highest mean intensity of *B*. *obsignata* was observed in autumn while there was no significant difference in the mean intensity of *A*. *columbae* with regards to season. Senlik *et al*. (2005) concluded that in regions with similar climatic conditions as those in the study area, pigeon breeders should be cautioned especially of *B*. *obsignata* and *A*. *columbae* infection of adult pigeons in the autumn months. Dovc *et al*. (2004) under took an epidemiological research on the health status of free-living pigeons in the city of Ljubljana, Slovenia. A total of 139 pigeons were captured and examined, *Capillaria* sp. occurred in 26.6% and *A*. *columbae* in 4.3% of droppings samples examined.

Mushi *et al*. (2000) examined 12 adult pigeons from Sebele, Garborone, Botswana for the presence of helminths, two nematodes *Dispharyx spiralis* (10.0%) and *Ascaridia columbae*

(30.0%) were recovered. Most pigeons (80.0%) were infected with *Ascaridia columbae* often in association with *Raillietina* spp.

Barus (1966) surveyed the nematodes parasites of birds in Czechoslovakia from 1955-1964. He autopsied a total of 500 birds and encounted *Ascaridia columbae*, *Heterakis gallinarum*, *Ancyclostoma anseris*, *Capillaria obsignata* and *Physaloptera* sp. in the Columbids.

In Nigeria, Atsineka and Banke (2006) reported on the following nematodes as parasites of domestic pigeons in Makurdi metropolis; *Ascaridia galli* (44.0%), *Heterakis gallinae* (18.0%), *Tetrameres* sp. (10.0%), *Amoebotaenia sphenoides* (4.0%) and *Chaonotaenia columbae* (2.0%). Oniye *et al*. (2000a) reported a prevalence of 2 (1.53%) for *Ascaridia galli* with two worms recovered from the small intestine of *Streptopelia sensgalensis* in Zaria, Nigeria. Audu *et al*. (2004) recovered *A*. *galli* from 6 (10.0%) *C*. *l*. *domestica* in Zaria, Nigeria. The sex-specificity of the parasite was 8.0% in males and 10.0% in females. Gadzama *et al*. (2005) recorded a prevalence of 1 (4.0%) for *Ascaridia galli* out of twenty five *S. senegalensis* examined in Zaria for helminths. Bankola and Adene (1989) reported *Ascaridia columbae* in pigeons in Ibadan while studying coccidiosis and ascaridiasis in pigeons. Abdullahi *et al*. (1992) reported on *Ascaridia* sp. in pigeons while studying the incidence of disease of poultry by non-viral infections agents in Zaria, Nigeria.

The *Capillaria*, *Ascaridia* and *Heterakis* species of nematodes are widely distributed in birds, causing non-specific clinical signs of the infection, such as loss of appetite and growth, a general loss in condition and on occasions, death (Hofstad *et al*., 1984).

Acanthocephala: The Acanthocephala are a group of parasitic worms that are considered closely related to the Nematodes. They are commonly called "thorny-headed worms", usually small worms with cylindrical body, lacking an alimentary canal. The eggs require to be ingested by an intermediate host, which is usually an arthropod (crustacean) and the final host acquires the infection by ingesting the infected intermediate host. The worms are usually located in the posterior part of the small intestine, where they penetrate deeply into the mucosa with their proboscis. The parasite produces anaemia, and heavy infections can cause severe losses of ducks or wild aquatic birds (Lapage, 1956). Diagnosis can be made by finding eggs in the faeces and carbon tetrachloride, tetrachlor-ethylene and nicotine preparations could be used for treatment for Acanthocephala (Lapage, 1956). *Polymorphus boschadis* and *Filicollis anatis* occur in the small intestine of duck, swan, fowl, goose and various wild aquatic birds but not in pigoens (Angus, 1978).

CHAPTER 3 MATERIALS AND METHODS

3.1 Study Area, Trapping and Identification of Columbids

The birds were trapped in Zaria area (11^0 03^1N and 07^0 42^1E) located in the Northern Guinea Savanna of Nigeria, from March, 2002 to February, 2004 (24 months). The dry season in Zaria lasts for a period of six months, November to April, and the rainy season is from May to October (Hore, 1970). The annual rainfall ranges between 1,000 mm to 1,114 mm (Happold, 1987). The average daily temperature is 36.6ºC in April and 23ºC in August. The relative humidity ranges from 70 –80% in August to about 15-20% in December (Yusuf and Associates, 1981).

According to Fry (1966), the Zaria area consists of ten major ecological associations. The natural vegetation is typically that of the Northern Guinea Savanna and is composed of shrubs, herbs, grasses and sparsely spaced trees. There are randomly located farmlands and also a good number of tall buildings surrounded by trees.The dominant trees within the area include *Mangifera indica*, *Gmelina* sp., *Delonix regia*, *Azadirachta indica*, *Eucalyptus citriodor*, *Albezi lebec*, *Khaya senegalensis*, *Spathodea campanulata*, *Piostigma* sp., *Pisidium guajava* and *Carica papaya*. Some of these trees serve as nesting, roosting, resting and feeding sites for the Columbids.

3.2 Columbids Sampled

A total of 736 Columbids were sampled for 24 months (March 2002-February 2004), and these consisted of 240 *Columba livia domestica* (127 males and 113 females), 382 *Streptopelia senegalensis* (231 males and 151 females), 48 *Streptopelia decipiens* (30 males and 18 females), 28 *Columba guinea* (20 males and 8 females), 32 *Turtur abyssinicus* (20 males and 12 females) and 6 *Streptopelia vinacea* (2 males and 4 females).

The wild birds (LD, MD, SP, BBWD and VD) were caught from farms and bushes in Zaria and its environs using locally made baited traps, string and wire traps. The trapped birds were identified with reference to Serle *et al*. (1992). The domestic pigeons (*C. l. domestica*) used for the study were bought from Samaru and Sabon-Gari markets in Zaria. Approximately 30 Columbids were sampled each month; 10 Domestic Pigeons and ± 20 wild Columbids based on their availability.

3.3 **Sex Determination**

In order to determine the sex of a bird, the cloaca was carefully examined as described by Miller and Wagner (1955). Any sign(s) or presence of cloaca protuberance was an indication of the male sex; such swellings are absent in the female. The sex of the bird was confirmed after slaughtering through clinical sexing for accuracy.

3.4 **Weight Determination**

The sartorius electric weighing balance of (CP 8201) was used to weigh the birds used in the study. Each bird was placed in a cardboard box of pre-determined weight, and then placed on the weighing balance. The weight of the bird was then determined by subtracting the weight of the box from the combined weight of the bird and the box.

3.5 **Determination of Packed Cell Volume (PCV)**

The packed cell volume was determined using the capillary micro haematocrit procedure (Coles, 1986). Blood was collected from the wing vein by puncturing it with a 23 guage needle. The microhaematocrit tubes (heparinized capillary tubes) were filled with blood and one end sealed using crystal seal. The tubes were then placed in a microhaematocrit

centrifuge and spun for three minutes at 503.2 g. The packed cell volume was then read using a haematocrit reader.

3.6 **Screening for Ectoparasites**

The plumage of each bird was thoroughly brushed onto a white tray to recover ectoparasites. The feathers of the head, the neck, under the wings, body, leg and cloaca were raised and thoroughly examined for ectoparasites with a hand lens. Attached ectoparasites such as ticks and mites, which could not be removed by brushing, were dislodged with a pair of thumb forceps and the sites of predilection the ectoparasites were noted. The ectoparasites were counted and preserved in labelled vials containing 70% alcohol and a drop of glycerine (Soulsby, 1982; Loomis, 1984).

The parasites were identified using standard texts by Soulsby (1982), Faust *et al*. (1962) and Cheesbrough (1990). Confirmatory identification of the parasites was made at the Entomology Laboratory of the Department of Veterinary Parasitology and Entomology, A.B.U., Zaria, Nigeria.

3.7 **Screening for Helminths**

After sacrificing each bird by cervical dislocation, the digestive tract was extracted intact and the various sections were separated and put in different Petri dishes containing physiological saline. Segments of the oesophagus were slit open, the crop was emptied and each was rinsed gently into Petri dishes and examined under a dissecting microscope for embedded helminths. The contents were also examined for freed parasites. The contents of the proventriculus and gizzard were washed separately into Petri dishes and the mucosae

were scrapped off and examined for parasites. Nodules were incised and embedded parasites were squeezed out (Ruprah *et al*., 1986).

The gastrointestinal tract, namely the duodenum, jejunum, ileum, caecum and rectum were examined separately in a similar manner. They were opened on a sieve and parasites in the lumen were collected and the contents were rinsed gently over a sieve placed under a slow-running tap water. The mucosal surfaces were rubbed carefully between fingers to remove adhering parasites (Ruprah *et al*., 1986). The mucosae were scrapped into petri dishes and observed under a dissecting microscope for helminths, which were collected and put in Petri dishes and counted. The parasites were then preserved in labeled sample bottles containing 10% buffered formalin. The nematodes were mounted in lactophenol and the cestodes were stained with Mayer's paracarmine. Identification was carried out by reference to Soulsby (1982), Reid (1984), Ruff (1984) and Ruprah *et al*. (1986). Confirmatory identification of the parasites was made at the Helminthology laboratory of the Department of Veterinary Parasitology and Entomology, A.B.U., Zaria, Nigeria.

3.8 **Experimental Infection of *Columba livia domestica* with *Ascaridia galli***

3.8.1 *Experimental birds*

A total of 60 domestic pigeons comprising of 30 males and 30 females, bought from Sabon-Gari and Samaru markets in Zaria, Nigeria were used for the experiment. The birds were housed in the Postgraduate Animal Laboratory in the Department of Biological Sciences, A.B.U., Zaria, Nigeria. The birds were acclimatized for a period of three weeks prior to the commencement of the experiment. During this period, the birds were treated for various parasites using the following drugs: Pip-pap powder for ectoparasites, Piperazine at

40 mg / kg / body weight for helminths, Amprolium at 25 mg / kg body / weight for coccidiosis and Chloroquin at 25 mg / kg / body weight for blood parasites. The parasites observed were *Menopon gallinae*, *Columbicola columbae* and *Pseudolynchia canariensis* (ectoparasites), cestode and nematode eggs, coccidia oocysts (intestinal parasites), *Haemoproteus* species and *Plasmodium* species (blood parasites).

At the end of the acclimatization period, the birds were divided into two groups of 30 birds each. The birds were shuffled irrespective of sex, based on their body weights to avoid any bias in the mean body weights of the two groups at the start of the experiment. Group A comprised of infected *C. l. domestica* while group B comprised of non-infected *C. l. domestica* (control). The birds in each group were tagged with numbers for proper identification during data collection. The birds were sexed as previously described in section 3.3.

3.8.2 *Production of infective eggs of Ascaridia galli*

Eggs used for infection were obtained from live adult female *A. galli* collected from pigeons slaughtered at Sabon-Gari, Samaru and Tudun Wada markets in Zaria, Nigeria.

The worms were collected in specimen bottles containing 0.9% physiologic saline and taken to the laboratory. In the laboratory, the worms were crushed using a mortar and pestle in distilled water to recover eggs from the uteri. The crushed worms were then filtered out into a beaker using a sieve mesh of 0.01 mesh size. The filtrate was then allowed to stand for about an hour after which the supernatant was decanted. The sediments were then washed with 0.5 M Sodium hydroxide solution into a beaker and agitated gently for 30 minutes in order to dissolve the sticky albuminous layer of eggs and allow for uniform sampling (Fairbairn, 1970). This was then distributed in centrifuge tubes and centrifuged at

251.6 g for 3 minutes to concentrate the eggs. The recovered eggs were then rinsed gently three times in distilled water and also three times in embryonating fluid (a solution of 0.05 M Sulphuric acid). The eggs collected were suspended in embryonating fluid and placed in plastic troughs. These were then left to stand for 12 days in an incubator at 30^{o}C. Embryonating fluid was periodically added to the eggs cultures to avoid drying, until the eggs became infective after 12 days of incubation. Embryonated eggs were stored at room temperature for two weeks before infection of the birds.

3.8.3 *Infection of birds with infective eggs*

The birds were infected with infective eggs of *A. galli* using the embryonated eggs produced earlier. Prior to infection, the eggs were washed three times in distilled water to remove the embryonating fluid. They were then suspended in a 1.25 M sucrose solution (Hensen *et al*., 1954) to prevent settling of the eggs. The viability of the embryonated eggs was tested by mild warming of drops of egg suspension on a glass slide and counting the number of eggs showing motile larvae under the microscope. The amount of egg suspension given to the birds in group A was calculated by multiplying the number of viable eggs in 0.01 ml of egg suspension. The birds were infected by taking equal amounts of agitated egg suspension with 5 ml syringe and injecting directly into the crop (Fatihu, 1990) using 20 G x 1.5 inch needles. Each birds in group A (infected birds) each received 0.75 ml of egg suspension containing 700 viable eggs. The birds in group B (uninfected birds) serving as control, were each given 0.75 ml of egg-free suspension fluid (sucrose solution).

The birds were weighed using an electric weighing balance and blood samples obtained before infection. After infection, the birds were weighed again and blood samples were obtained on weekly bases for determination of packed cell volume (PCV), total plasma protein and haemoglobin level. The birds were also weighed using an electric weighing balance of model (CP 8201). The blood samples were obtained by saphenous venepunture using 20 G x 1½ inches needles collected using heparinised capillary tube. Packed Cell Volume (PCV) was determined using capillary microhaematocrit procedure (Coles, 1986). Plasma protein values were obtained from plasma in the capillary tubes, by putting 1-2 drops on total solids meter, hand refractometer and reading the plasma protein concentration directly in g/100 ml. Haemoglobin level values were determined by dividing the PCV values by a factor of three (Coles, 1986). Faecal sample examination was conducted using the simple floatation technique, from the second week after infection, until infection was ascertained by detection of ascarid eggs in the faeces of infected birds 5-6 weeks post infection. The experiment was terminated on the 12th week after infection. The infected birds were sacrificed and the number of worms recovered from each bird was recorded.

3.8.4 *Histopathology*

Sections of the liver, lungs, heart, kidneys and intestine from the freshly sacrificed infected birds were immediately taken to the Histopathology Laboratory of the Department of Veterinary Pathology and Microbiology of the Veterinary Teaching Hospital, ABU, Zaria for histopathological analysis.

3.9 **Data and Statistical analysis**

The prevalence, intensity and mean intensity of the parasites were calculated as described by Margolis *et al*. (1982). A one-way analysis of variance (ANOVA) using a statistical soft ware (Epi-infos 6.0 windows version) was used to determine significant differences in the prevalence, intensity and mean intensity of the parasites.

Prevalence of single infections (number of birds having only one parasite species) and mixed infections (number of birds having two or more parasite species) were expressed as percentages.

Sex-specific infections, the number of males and females infected with a particular parasite species, were also expressed as percentages. Chi square was used to determine possible association between sex and season with parasite infestation and infection. Monthly prevalence was calculated as described by Margolis *et al*. (1982). A one way analysis of variance (ANOVA) was used to determine significant differences in the monthly prevalence of various parasites within the months.

A meteorological data from March 2002 to February 2004 for rainfall, relative humidity and temperature (Appendix 21) was collected from the Institute for Agricultural Research (IAR) Samaru, Zaria, Nigeria, to determine any correlation with monthly prevalence of ecto- and helminth parasites of Domestic Pigeon and Laughing Dove using the Pearson correlation coefficient.

The data on body weights, PCV, Hb level and total plasma protein, collected from the infection of *C. l. domestica* with *A. galli* was subjected to statistical analysis using the analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) (Philips, 1978).

3.10 **Photography and Photomicrography**

Photographs of the Columbids were taken in the laboratory using a zoom lens camera. Photomicrographs of the ectoparasites and helminths were taken at the Department of Biological Sciences, A.B.U., Zaria, while those of histopathology were taken at the Department of Veterinary Microbiology and Pathology, A.B.U., Zaria.

CHAPTER 4 RESULTS

4.1 **Ectoparasites of *Columba livia domestica***

4.1.1 *Prevalence of ectoparasites*

Out of the 240 *C. l. domestica* examined, 177 (73.8%) were infested by ectoparasites. The ectoparasites encountered were lice, flies and mites. The lice species encountered included *Menopon gallinae* in 15 (6.3%), *Columbicola columbae* in 153 (63.8%) and *Goniodes* sp. in 26 (10.8%). The only fly encounted was *Pseudolynchia canariensis* in 89 (37.1%) and the mite species encountered was *Dermanyssus gallinae* in 6 (2.5%) of the 240 birds (Plate VII-XI, Table 4.1 and Appendix 1).

A total of 3306 parasites were recovered and the relative abundance of the parasites were *Menopon gallinae* 83 (2.5%), *Columbicola columbae* 2743 (82.9%), *Goniodes* sp. 149 (4.5%), *Pseudolynchia canariensis* 322 (9.7%) and *Dermanyssus gallinae* 9 (0.3%). The mean intensities of the ectoparasites were: *Menopon gallinae* 5.5 ± 0.5, *Columbicola columbae* 17.9 ± 0.8, *Goniodes* sp 5.7 ± 0.7, *Pseudolynchia canariensis* 3.6 ± 0.2 and *Dermanyssus gallinae* 1.5 ± 0.2 (Table 4.1 and Appendix 3)

Menopon gallinae and *Goniodes* sp. were recovered from the head, neck and body, *C. columbae* from quill feathers of the wings and tail, *P. canariensis* from the down and contour feathers of the skin, and *D. gallinae* from the body and legs.

There were significant differences between the prevalence, intensity and mean intensity of the ectoparasites ($P<0.05$).

Table 4.1: Prevalence and predilection sites on ectoparasites of *Columba livia domestica* in Zaria, Nigeria (n=240)

Parasite	Number of Columbids infested	Prevalence (%)	Total number recovered (%)	Mean intensity ± SE	Range	Site of recovery
Lice						
Columbicola columbae	153	63.8	2743 (82.9)	17.9±0.8	2-52	Quill feathers of wings and tail
Menopon gallinae	15	6.3	83 (2.5)	5.5±0.5	1-34	Body, head and neck
Goniodes sp.	26	10.8	149 (4.5)	5.7±0.7	1- 9	Body, head and neck
Fly						
Pseudolynchia canariensis	89	37.1	322 (9.7)	3.6±0.2	1- 9	Down and Contour feathers of body
Mite						
Dermanyssus gallinae	6	2.5	9 (0.3)	1.5±0.2	1- 2	Legs and body
Total	177	73.8	3306 (100.0)	18.7±0.6	1-52	Plumage

A



B

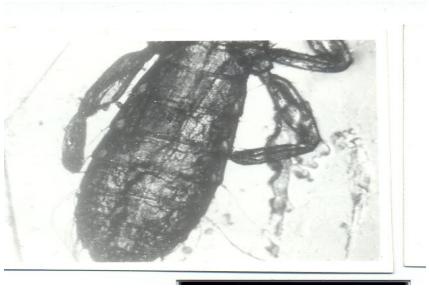


Plate VII: Anterior (A) and posterior (B) ends of *Columbicola columbae* recovered from *C. l. domestica*, *S. senegalensis*, *S. decipiens*, *C. guinea*, *T. abyssinicus* and *S. vinacea* Mg X40

A



B

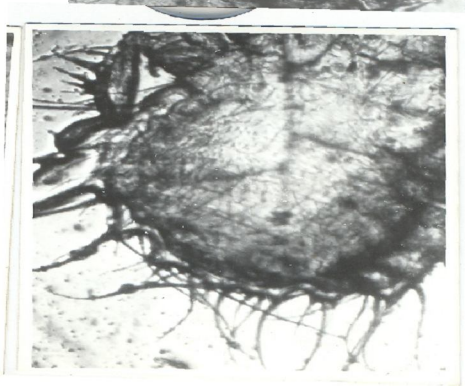
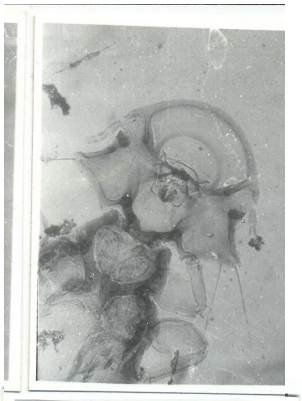


Plate VIII: Anterior (A) and posterior (B) ends of *Menopon gallinae* recovered from *C. l. domestica*, *S. senegalensis*, *S. decipiens*, *C. guinea*, *T. abyssinicus* and *S. vinacea* Mg X40

A



B



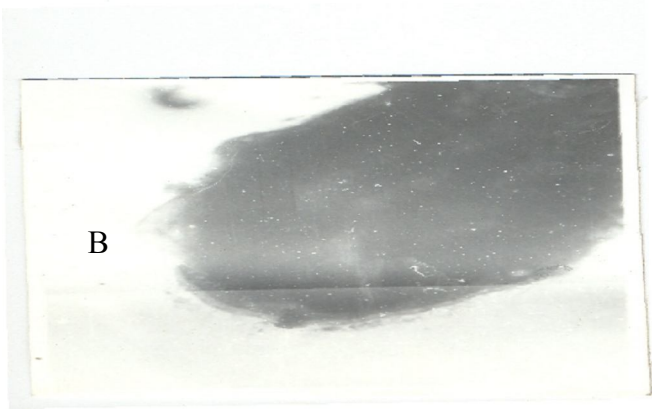
Plate IX: Anterior (A) and posterior (B) ends of *Goniodes* sp. recovered from *C. l. domestica* and *S. senegalensis* Mg X40



Plate X: *Pseudolynchia canariensis* recovered from *C. l. domestica*, *S. senegalensis*, *S. decipiens*, *C. guinea* and *S. vinacea* Mg X40

A





B

Plate XI: Anterior (A) and posterior (B) ends of *Dermanyssus gallinae* recovered from *C. l. domestica* and *S. senegalensis* Mg X40

4.1.2 *Intensity of ectoparasite infestations*

Table 4.2 shows the intensity of ectoparasite infestations on *C. l. domestica* in Zaria. The number of individuals in the lower class intervals of 1-5, 6-10, 11-15, 16-20 and 21-25 (with low parasite burden) were more than those in the higher class intervals of 26-30, 31-35, 36-40, 41-45, 46-50 and 51-55 (with high parasite burden).

4.1.3 *Frequency distribution of single and mixed infestations*

Prevalence of mixed infestations (43.0%) were higher than that of single infestations (30.8%), though the difference was not significant (P>0.05) (Table 4.3).

4.1.4 *Sex-related ectoparasite infestations of Columba livia domestica*

A total of 127 males and 113 females were examined and the prevalence of ectoparasites in the male birds was 93 (73.2%) and 84 (74.3%) in the females. A total of 1,873 (56.8%) ectoparasites were recovered from males and 1,433 (43.3%) from the females. Mean intensity in males was 20.2 ± 0.6 and 17.1 ± 0.7 in females (Table 4.4, 4.5, Appendix 2 and 4). Chi square analysis showed no significant association between sex and ectoparasite infestation (P>0.05).

4.2.5 *Effects of ectoparasite infestations on body weight and PCV*

The body weights and PCV of infested and non–infested pigeons were between 160-385 g and 35-65 % respectively, and there was no significant difference between the mean body weights and mean PCV values of infested (252.4±6.2 g, 57±0.7 %) and non-infested (259.4±4.2 g, 57±0.7 %) pigeons (P>0.05).

Table 4.2: Intensity of ectoparasite infsetations on *C. l. domestica* in Zaria, Nigeria

	Ectoparasites and frequency of intensity					
Class interval	*Columbicola Columbae*	*Menopon Gallinae*	*Goniodes* sp.	*Pseudolynchia canariensis*	*Dermanyssus gallinae*	Total (%)
1-5	9	7	15	78	6	115 (48.0)
6-10	13	8	11	11	0	43 (17.9)
11-15	54	0	0	0	0	54 (22.5)
16-20	32	0	0	0	0	32 (13.3)
21-25	23	0	0	0	0	23 (9.6)
26-30	7	0	0	0	0	7 (2.9)
31-35	5	0	0	0	0	5 (2.1)
36-40	2	0	0	0	0	2 (0.8)
41-45	3	0	0	0	0	3 (1.3)
46-50	3	0	0	0	0	3 (1.3)
51-55	2	0	0	0	0	2 (0.8)
Total		15 (6.3%)	26 (10.8%)	89(37.1%)	6 (2.5%)	

Table 4.3: Frequency distribution of single and mixed ectoparasite infestations on *Columba livia domestica* in Zaria, Nigeria

Infestation Type	Parasite	Frequency of occurrence Total	Percentage (%)
None		63	26.3
Single infestation	*Menopon gallinae*	2	
	Columbicola columbae	51	
	Pseudolynchia canariensis	20	
	Dermanyssus gallinae	1	
Total		74	30.8
Double infestation	*Menopon gallinae* + *Columbicola columbae*	7	
	Menopon gallinae + *Pseudolynchia canariensis*	1	
	Columbicola columbae + *Pseudolynchia canariensis*	62	
	Columbicola columbae + *Goniodes* sp.	23	
	Columbicola columbae + *Dermanyssus gallinae*	2	
Total		95	39.6
Triple infestation	*M. gallinae* + *C. columbae* + *P. canariensis*	4	
	M. gallinae + *C. columbae* + *D. gallinae*	1	
	C. columbae + *P. canariensis* + *Goniodes* sp.	1	
	C. columbae + *Goniodes* sp. + *D. gallinae*	1	
Total		7	2.9
Quadruple infestation	*C. columbae* + *P. canariensis* + *Goniodes* sp. + *D. gallinae*	1	0.4
Grand total		177	73.8

Table 4.4: Prevalence of ectoparasites on male *Columba livia domestica* in Zaria, Nigeria (n=127)

Parasite	Number of birds infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ± SE	Range	Site of recovery
Lice						
Columbicola columbae	85	66.9	1608 (85.7)	18.9±1.0	2-52	Quill feathers of wings and tail
Menopon gallinae	4	3.1	19 (1.0)	4.8±0.5	1-34	Body, head and neck
Goniodes sp.	13	10.2	74 (3.9)	5.7±0.9	1- 9	Body, head and neck
Fly						
Pseudolynchia canariensis	49	38.6	169 (9.0)	3.4±0.3	1- 9	Down and Contour feathers of body
Mite						
Dermanyssus gallinae	2	1.6	3 (0..2)	1.5±0.5	1- 2	Legs and body
Total	93	73.2	1873 (100.0)	0.2±0.6	1-52	Plumage

Table 4.5: Prevalence of ectoparasites on female *Columba livia domestica* in Zaria, Nigeria (n=113)

Parasite	Number of birds infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ± SE	Range	Site of recovery
Lice						
Columbicola columbae	68	60.2	1135 (79.2)	16.7±1.2	2-52	Quill feathers of wings and tail
Menopon gallinae	11	9.7	64 (4.5)	5.8±0.6	1-34	Body, head and neck
Goniodes sp.	13	11.5	75 (5.2)	5.8±1.2	1- 9	Body, head and neck
Fly						
Pseudolynchia canariensis	40	35.4	153 (10.7)	3.8±0.3	1- 9	Down and Contour feathers of body
Mite						
Dermanyssus gallinae	4	3.5	6 (0.4)	1.5±0.3	1- 2	Legs and body
Total	84	74.3	1433 (100.0)	17.1±0.7	1-52	Plumage

4.1.6 *Monthly prevalence and intensity of ectoparasites*

The monthly prevalence of ectoparasites *on C. l. domestica* varied throughout the year, howevr the highest prevalence (95.0%) was in August (rainy season) while the least (55.0%) was in February (dry season) (Figure 4.1). The mean monthly intensity was highest in August 30.3 ± 2.5, and lowest in June 10.9 ± 1.0.

Overall prevalence in the wet months (78.3%) was higher than in the dry (62.2%). There was a marked association of ectoparasite infestations with the wet months than with the dry months. Mean intensity in the wet months (21.3 ± 0.2) was higher than that of the dry months (15.7 ± 0.3) but the difference was not significant ($P>0.05$). A positive correlation was observed between ectoparasite infestations, rainfall and relative humidity (Appendix 21 and 22).

The monthly prevalence of each ectoparasite of *C. l. domestica* is presented in Figure 4.2, while the monthly prevalence, intensity and mean monthly intensity of individual ectoparasites on *C. l. domestica* are presented in Appendix 9.

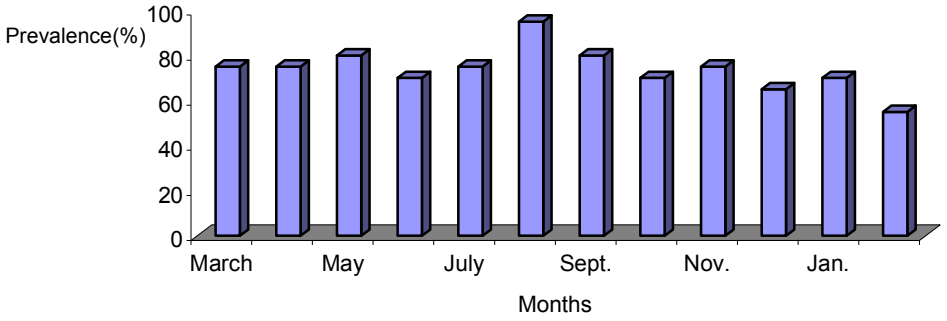


Figure 4.1: Total Monthly prevalence of ectoparasites on *C. l. domestica* in Zaria, Nigeria (2002 – 2004)

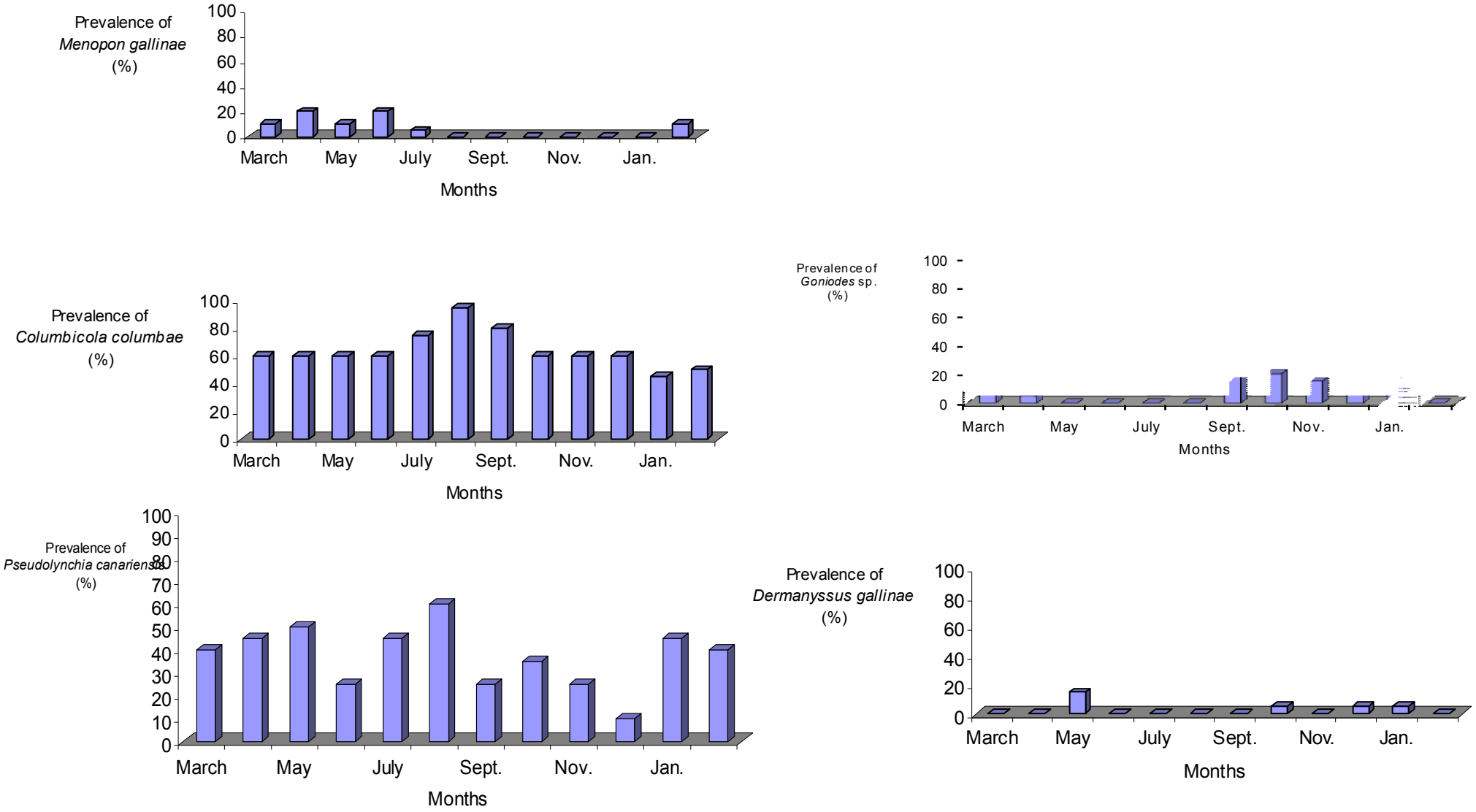


Figure 4.2: Monthly Prevalence of individual ectoparasites on *C.l. domestica* in Zaria, Nigeria

Menopon gallinae was recovered in six months with highest prevalence (20.0%) in April and June and lowest prevalence (5.0%) in July. The highest mean monthly intensity for *M. gallinae* was 8.0 ± 0.0 in July and the lowest was 4.0 ± 0.8 in June.

Columbicola columbae was recovered from the birds in all the months of the year, with highest prevalence (95.0%) in August and lowest (45.0%) in January. The highest mean monthly intensity for *C. columbae* was 27.2 ± 3.0 in August and lowest was 9.8 ± 1.3 in June.

Pseudolynchia canariensis was recovered in all the months of the year with highest prevalence (60.0%) in August and lowest (10.0%) in December. The highest mean monthly intensity for *P. canariensis* was 4.9 ± 0.6 in August and lowest was 2 .4 ± 0.3 in January.

Goniodes sp. was recovered in seven months of the year with the highest prevalence (40.0%) in December and lowest (5.0%) in April. The highest mean monthly intensity for *Goniodes* sp. was 9.3 ± 2.3 in October and the lowest was 2.5 ± 0.5 in March.

Dermanyssus gallinae was recovered in four months, May, October, December and January with highest prevalence (15.0%) in May and lowest (5.0%) in October, December and January. The highest mean monthly intensity for *D. gallinae* was 2.0 ± 0.3 for October and the lowest was 1.0 ± 0.0 for December and January. There were significant differences between the prevalence and mean monthly intensity of various ectoparasites ($P<0.05$).

4.2 **Helminths of *Columba livia domestica***

4.2.1 *Prevalence of helminths*

Out of the 240 *Columba livia domestica* examined, 116 (48.3%) were infected by helminths. Nine species of helminths were identified, comprising of six cestodes and three nematodes. Sixty-five (27.1%) of the birds were infected by *Raillietina tetragona,* 26 (10.8%) had *R. echinobothrida*, 1 (0.4%) had *R. cesticillus*, 2 (0.8%) had *Amoebotaenia cuneata,* 3 (1.3%) had *Hymenolepis carioca* and 4 (1.7%) had *H. cantaniana* while 27 (11.3%) had *Ascaridia columbae*, 8 (3.3%) had *A. galli* and 8 (3.3%) had *Heterakis gallinarum* (Plate XII –XX, Table 4.6 and Appendix 5).

A total of 1778 parasites were recovered and the relative abundance of these helminths were *R. tetragona* 1145 (64.5%), *R. echinobothrida* 179 (10.1%), *R. cesticillus* 1 (0.05%), *Amoebotaenia cuneata* 11 (0.6%), *H. carioca* 35 (2.0%), *H. cantaniana* 24 (1.4%), *A. columbae* 285 (19.9%), *A. galli* 76 (4.3%) and *Heterakis gallinarum* 22 (1.2%). The mean intensities of the helminths were: *R. tetragona* 17.6±5.1, *R. echinobothrida* 6.9±1.0, *R. cesticillus* 1.0±0.0, *Amoebotaemia cuneata* 5.5 ± 2.5, *H. carioca* 11.7 ± 2.5, *H. cantaniana* 6.0 ± 2.0, *A. columbae* 10.6 ± 2.8, *A. galli* 9.5 ± 4.7, *Heterakis gallinarum* 2.8 ± 0.5. The predilection sites of *R. tetragona* and *R. echinobothrida* were in the duodenum and ileum, while *R. cesticillus* was restricted to the ileum, *A. cuneata*, *H. carioca* and *H. cantaniana* were in the duodenum. The nematodes, *A. columbae* and *A. galli* were in the duodenum and ileum while *Heterakis gallinarum* was restricted to the caeca (Table 4.6 and Appendix 7). There were statistically significant differences in the prevalence and mean intensity between the helminths ($P<0.05$).

Table 4.6: Prevalence and predilection sites of intestinal helminths in *Columba livia domestica* in Zaria, Nigeria (n=240)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	65	27.1	1145 (64.4)	17.6±5.1	2-61	Duodenum/ileum
Raillietina echinobothrida	26	10.8	179 (10.1)	6.9 ±1.0	2-21	Duodenum/ileum
Raillietina cesticillus	1	0.4	1 (0.1)	1.0±0.0	1- 1	Ileum
Amoebotaenia cuneata	2	0.8	11 (0.6)	5.5±2.5	3- 8	Duodenum
Hymenolepis carioca	3	1.3	35 (2.0)	11.7±2.5	3-24	Duodenum
Hymenolepis cantaniana	4	1.7	24 (1.3)	6.0±2.0	2-11	Duodenum
Heterakis gallinarum	8	3.3	22 (1.2)	2.8±0.5	1-4	Caeca
Ascaridia galli	8	3.3	76 (4.3)	9.5±4.7	2-41	Duodenum/ileum
Ascaridia columbae	27	11.3	285 (16.0)	10.6±2.8	1- 54	Duodenum/ileum
Total	116	48.3	1778 (100.0)	15.3±1.0	1-61	Small intestine

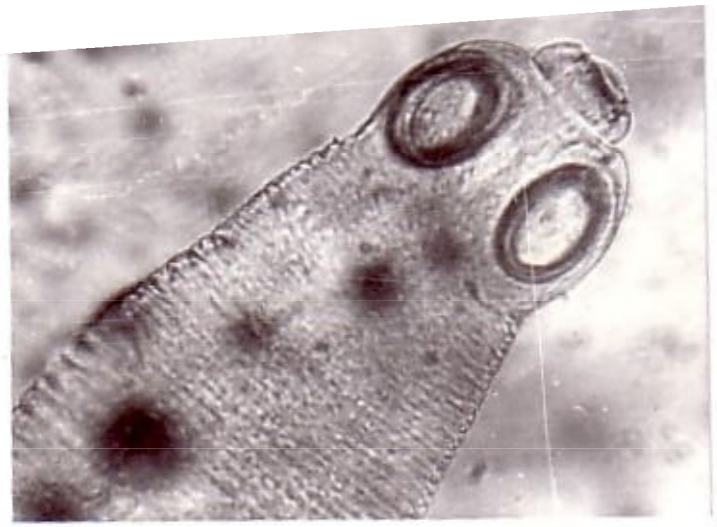


Plate XII: Anterior end of *Raillietina tetragona* recovered from *C. l. domestica*, *S. senegalensis*, *S. decipiens*, *C. guinea* and *T. abyssinicus* Mg X40



Plate XIII: Anterior end of *Raillietina echinobothrida* recovered from *C. l. domestica*, *S. senegalensis* and *T. abyssinicus* Mg X40



Plate XIV: Anterior end of *Raillietina cesticillus* recovered from *C. l. domestica*, *S. senegalensis*, *S. decipiens*, *C. guinea*, *T. abyssinicus* and *S. vinacea* Mg X40



Plate XV: Anterior end of *Amoebotaenia cuneata* recovered from recovered from *C. l. domestica*, *S. senegalensis*, *S. decipiens*, *C. guinea* and *T. abyssinicus* Mg X40



Plate XVI: Anterior end of *Hymenolepis carioca* recovered from *C. l. domestica*, *S. senegalensis*, *S. decipiens*, *C. guinea* and *S. vinacea* Mg X40

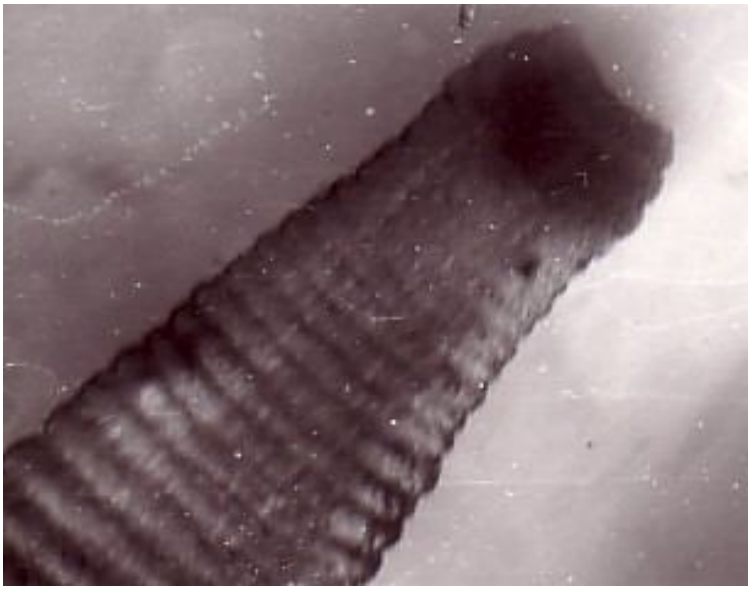


Plate XVII: Anterior end of *Hymenolepis cantaniana* recovered from *C. l. domestica*, *S. senegalensis*, *S. decipiens* and *S. vinacea* Mg X40



Plate XVIII: Anterior end of *Heterakis gallinarum* recovered from *C. l. domestica* and *S. senegalensis* Mg X40

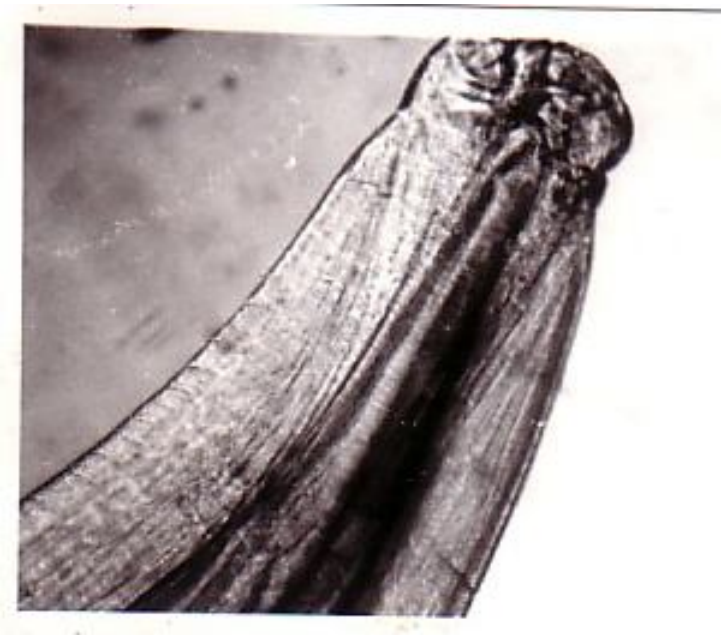


Plate XIX: Anterior end of *Ascaridia galli* recovered from *C. l. domestica* and *S. senegalensis* Mg X40



Plate XX: Anterior end of *Ascaridia columbae* recovered from *C. l. domestica* only Mg X40

4.2.2 *Intensity of helminth infections*

Table 4.7 shows the intensity of helminth infections in *C. l. domestica*. The number of individuals in the lower class intervals of 1-5, 6-10, 11-15, 16-20 and 21-25 (with low parasite burden) were more than those in the higher class intervals of 26-30, 31-35, 36-40, 41-45, 46-50 and 51-55, 56-60 and 61-65 (with high parasite burden).

4.2.3 *Frequency distribution of single and mixed infections*

Single infections 90 (37.5%) were most prevalent than double 24 (10.0%) and triple infections 02 (0.8%) (Table 4.8).

4.2.4 *Sex-related helminth infections of Columba livia domestica*

A total of 127 males and 113 females were examined and helminth infections in the male birds was 68 (53.5%) and 48 (42.5%) in the females (Table 4.9, 4.10, Appendix 6 and 8). A total of 886 (49.8%) helminths were recovered from the males and 892 (50.2%) from the females and mean intensity was 13.0 ± 1.0 in males and 18.6 ± 2.0 in females. Chi-square test showed no significant association between sex and infection ($P > 0.05$).

Table 4.7: Intensity of helminth infections in *C. l. domestica* in Zaria, Nigeria

	Helminths and frequency of intensity									
Class interval	*Raillietina tetragona*	*Raillietina echinobothrida*	*Raillietina Cesticillus*	*Amoebotaenia Cuneata*	*Hymenolepis carioca*	*Hymenolepis cantaniana*	*Heterakis gallinarum*	*Ascaridia galli*	*Ascaridia columbae*	Total (%)
1-5	9	12	1	1	1	2	8	4	16	54 (22.5)
6-10	12	9	0	1	1	1	0	3	3	30(12.5)
11-15	12	2	0	0	0	1	0	0	2	17(7.1)
16-20	9	2	0	0	0	0	0	0	0	11(4.6)
21-25	10	1	0	0	1	0	0	0	1	13(5.4)
26-30	5	0	0	0	0	0	0	0	0	5(2.1)
31-35	2	0	0	0	0	0	0	0	1	3(1.3)
36-40	1	0	0	0	0	0	0	0	1	2(0.8)
41-45	2	0	0	0	0	0	0	1	2	5(2.1)
46-50	1	0	0	0	0	0	0	0	0	1(0.4)
51-55	0	0	0	0	0	0	0	0	1	1(0.4)
56-60	1	0	0	0	0	0	0	0	0	1(0.4)
61-65	1	0	0	0	0	0	0	0	0	1(0.4)
Total	65 (27.1)	26 (10.8)	1 (0.4)	2 (0.8)	3 (1.3)	4 (1.7)	8 (3.3)	8 (3.3)	27 (11.3)	

Table 4.8: Frequency distribution of single and mixed infections of helminths in *C. l. domestica* in Zaria, Nigeria

Infection type	Parasite	Frequency of occurrence	
		Total	Percentage (%)
None		124	51.7
Single	*Raillietina tertragona*	49	
	Raillietina echinobothrida	18	
	Amoebotaenia cuneata	2	
	Hymenolepis carioca	2	
	Hymenolepis cantaniana	2	
	Ascaridia columbae	14	
	Ascaridia galli	2	
	Heterakis gallinarum	1	
Total		90	37.5
Double	*Raillietina tertragona* + *Ascaridia columbae*	6	
	Raillietina tertragona + *Ascaridia galli*	2	
	Raillietina tertragona + *Heterakis gallinarum*	6	
	Raillietina echinobothrida + *Ascaridia columbae*	6	
	Raillietina echinobothrida + *Ascaridia galli*	2	
	Raillietina cesticillus + *Ascaridia columbae*	1	
	Hymenolepis cantaniana + *Heterakis gallinarum*	1	
Total		24	10.0
Triple	*Raillietina tertragona* + *Hymenolepis carioca*+ *Ascaridia galli*	1	
	Raillietina tetragona + *Hymenolepis cantaniana* + *Ascaridia galli*	1	
Total		2	0.8
Grand total		116	48.3

Table 4.9: Prevalence and predilection sites of intestinal helminths in male *Columba livia domestica* in Zaria, Nigeria (n=127)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	39	30.7	593 (66.9)	15.2±1.3	2-61	Duodenum/ileum
Raillietina echinobothrida	14	11.0	110 (12.4)	7.9 ±1.4	2-21	Duodenum/ileum
Amoebotaenia cuneata	1	0.8	3 (0.3)	3.0±0.0	1-3	Duodenum
Hymenolepis carioca	3	2.4	35 (4.0)	11.7±0.5	8-24	Duodenum
Hymenolepis cantaniana	3	2.4	13 (1.5)	4.3±1.5	2-11	Duodenum
Heterakis gallinarum	4	3.1	14 (1.6)	3.5±0.6	1-4	Caeca
Ascaridia galli	4	3.1	56 (6.3)	4.0±9.2	2-41	Duodenum/ileum
Ascaridia columbae	13	10.2	62 (7.0)	4.8±1.6	1- 54	Duodenum/ileum
Total	68	53.5	886 (100.0)	13.0±1.0	1-61	Small intestine

Table 4.10: Prevalence and predilection sites of intestinal helminths in female *Columba livia domestica* in Zaria, Nigeria (n=113)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	26	23.0	552 (61.9)	21.2±3.4	2-60	Duodenum/ileum
Raillietina echinobothrida	12	10.6	69 (7.7)	5.8 ±1.5	2-21	Duodenum/ileum
Raillietina cesticillus	1	0.9	1 (0.1)	1.0±0.0	1-1	Ileum
Amoebotaenia cuneata	1	0.9	8 (0.9)	8.0±0.0	1-8	Duodenum
Hymenolepis cantaniana	1	0.9	11 (1.2)	11.0±1.5	1-11	Duodenum
Heterakis gallinarum	4	3.5	8 (0.9)	2.0±0.6	2-41	Caeca
Ascaridia galli	4	3.5	20 (2.2)	5.0±1.7	1-45	Duodenum/ileum
Ascaridia columbae	14	12.4	223(25.0)	15.9±4.9	2-11	Duodenum
Total	48	42.5	892 (100.0)	18.6±2.0	1-60	Small intestine

4.2.5 *Effects of helminth infections on body weight and PCV*

The body weights and PCV values of infected and non-infected pigeons were within 160-385 g and 35-65% respectively and the unpaired t-test showed no significant difference between the mean body weights and mean PCV values of 252.9 ± 9.32 g, 50 ± 2.17 % for infected and 260.5 ± 3.45 g, 56 ± 0.88 % for non-infected pigeons ($P>0.05$).

4.2.6 *Monthly prevalence and intensity of helminths*

Helminths were recovered from *C. l. domestica* in eleven months of the year with highest prevalence (80.0%) in June and September (wet season) and lowest prevalence (30.0%) in March, April, December and January (dry season) (Figure 4.3). Overall prevalence in the wet season (65.0%) was higher than in the dry season (31.7%). Chi square test showed a marked association of infection with the wet season and a significant difference in prevalence between the wet and dry season.

The mean monthly intensity was highest 23.9 ± 3.7 in June and lowest 7.0 ± 3.00 in December. Mean intensity in the wet season (17.4 ± 2.6) was higher in the dry season (11.1 ± 1.2). A positive correlation was observed between helminth infection, rainfall and relative humidity (Appendix 21 and 22).

The monthly prevalence of each helminth of *C. l. domestica* is presente in Figure 4.4, while the monthly prevalence, intensity and mean monthly intensity of individual helminths in *C. l. domestica* are presented in Appendix 10.

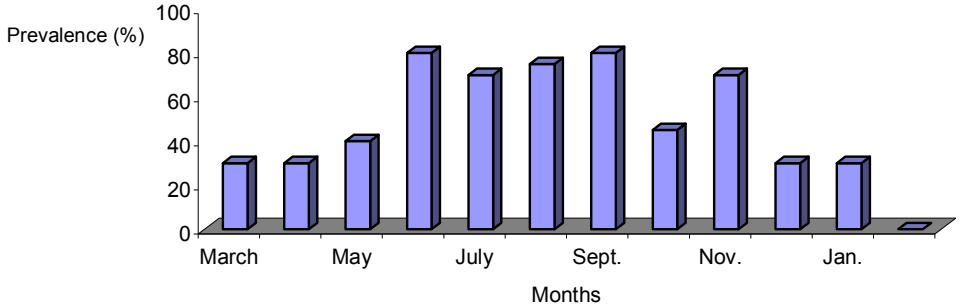


Figure 4.3: Total Monthly prevalence of helminths in *C. l. domestica* in Zaria, Nigeria (2002 – 2004)

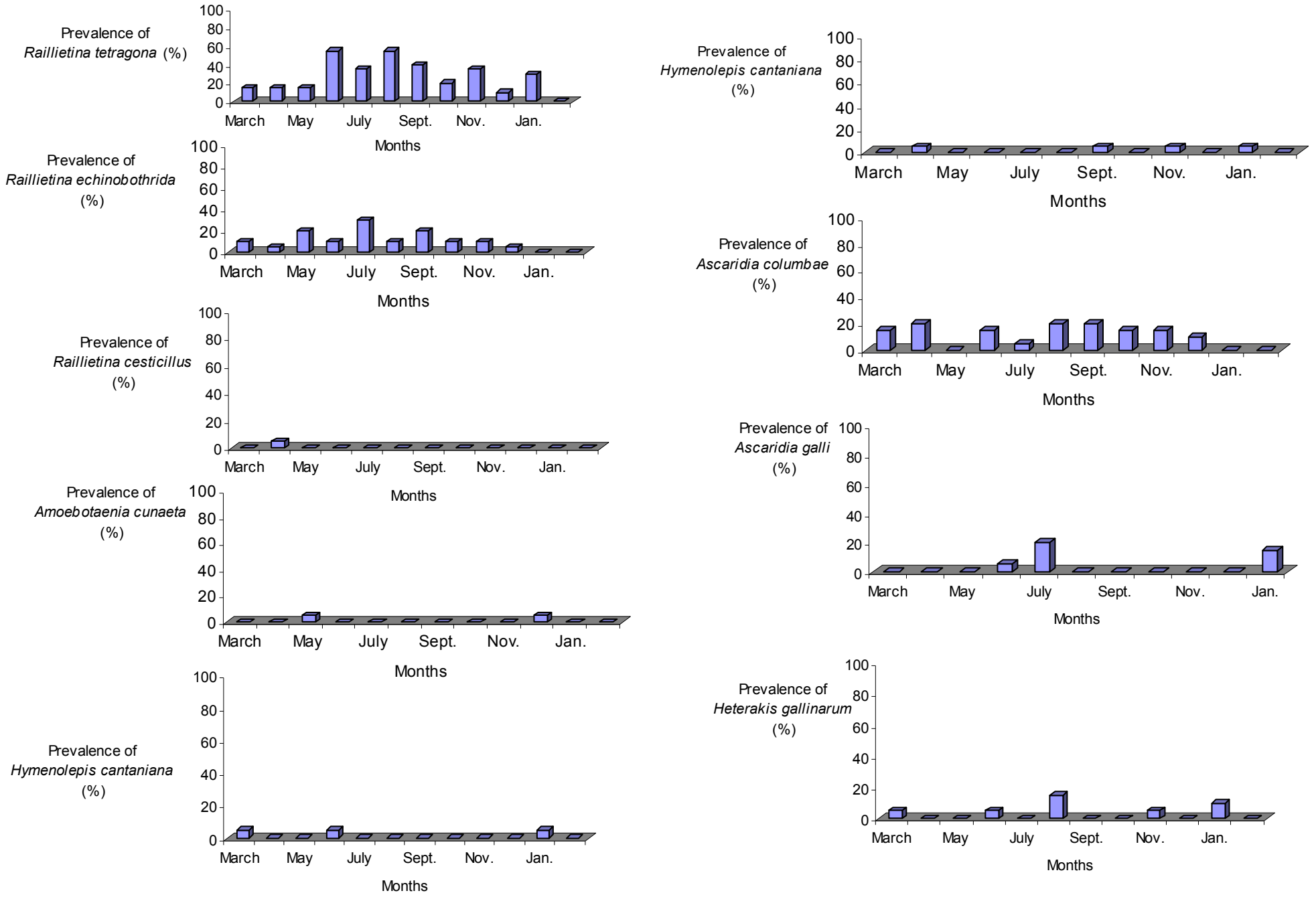


Figure 4.4: Monthly prevalence of individual helminths in *C. l. domestica* in Zaria, Nigeria

Raillietina tetragona was recovered from the birds in eleven months (March to January) with highest prevalence (55.0%) in June and August and lowest (10.0%) in December. The highest mean monthly intensity for *R. tetragona* was 29.3 ± 5.8 in June and the lowest was 6.0±2.0 in December. *Raillietina echinobothrida* was recovered from the birds in ten months with the highest prevalence (30.0%) in July and lowest (5.0%) in April and December. The highest mean monthly intensity for *R. echinobothrida* was 20.5±3.7 in June and the lowest was 2.0±0.0 in April and December. *Raillietina cesticillus* was recovered in April only with a prevalence of 5.0% and mean monthly intensity of 1.0±0.0. *Amoebotaenia cuneata* was recovered in May with a prevalence of 5.0% and mean intensity of 8.0±0.0 and in December with a prevalence of 5.0% and mean intensity of 3.0±0.0. *Hymenolepis carioca* was recovered from the birds in March with a prevalence of 5.0% and mean intensity of 24.0±0.0, in June with a prevalence of 5.0% and mean intensity of 8.0±0.0 and in January with a prevalence of 5.0% and mean intensity of 3.0±0.0. *Hymenolepis cantaniana* was recovered in April, September, November and January, with equal prevalence of 5.0% each. The highest mean monthly intensity was 11.0±0.0 in September and the lowest was 2.0 ± 0.1 in January.

Ascaridia columbae was recovered in nine months of the year, with highest prevalence (20.0%) in April, August and September and lowest (5.0%) in July. The highest mean monthly intensity was 19.7±17.5 in October and the lowest 2.0±3.0 in June. *Ascaridia galli* was recovered from the birds in June, July and January. The highest prevalence was (20.0%) in July and lowest (5.0%) in June. The highest mean monthly intensity was

15.3±8.8 in July and the lowest was 2.0±0.0 in June. *Heterakis gallinarum* was recovered in five months with the highest prevalence (15.0%) in August and lowest (5.0%) in March, June and November. The highest mean monthly intensity was 4.0±0.0 in June, November and January while the lowest was 1.3±0.3 in August.

4.3 **Ectoparasites of *Streptopelia senegalensis***

4.3.1 *Prevalence of ectoparasites*

Out of the 382 Doves examined 88 (23.0%) were infested with ectoparasites.

Six types of ectoparasites were recovered and these included the speices of lice *Menopon gallinae* 32 (8.4%), *Columbicola columbae* 37 (9.7%) and *Goniodes* sp. 18 (4.7%) one species of fly *Pseudolynchia canariensis* 19 (5.0%), one species of tick *Argas persicus* 12 (3.1%) and mite *Dermanyssus gallinae* 1 (0.26%) (Plate VII-XI, XXI Table 11 and Appendix 1).

A total of 668 parasites were recovered and the relative abundance of the parasites were *Menopon gallinae* 136 (20.4%), *Columbicola columbae* 307 (46.0%), 121(18.1%) *Goniodes* sp., *Pseudolynchia canariensis* 46 (6.9%), *Argas persicus* 57 (8.5%) and *Dermanyssus gallinae* 01 (0.15%). The mean intensities of the ectoparasites were: *Menopon gallinae* 4.3 ± 0.4, *Columbicola columbae* 8.3 ± 0.8, *Goniodes* sp. 6.7 ± 1.1, *Pseudolynchia canariensis* 2.4 ± 0.2, *Argas persicus* 4.8 ± 0.8 and *Dermanyssus gallinae* 1.0 ± 0.0. *Menopon gallinae* and *Goniodes* sp. were recovered from the head, neck and body, *C. columbae* from quill feathers of the wings and tail, *P. canariensis* from the down and contour feathers of the skin, *Argas persicus* from the wing web and thigh and

Dermanyssus gallinae from the body and legs (Table 4.11 and Appendix 3). There were significant differences between the prevalence and between the mean intensity of the ectoparasites ($P<0.05$).

4.3.2 *Intensity of ectoparasite infestations*

Table 4.12 shows the intensity of ectoparasite infestations on *Streptopelia senegalensis* in Zaria. The number of individuals in the lower class intervals of 1-5, 6-10 and 11-15 (with low parasite burden) were more than those in the higher class intervals of 16-20 and 21-25 (with high parasite burden).

4.3.3 *Frequency distribution of single and mixed infestations*

Prevalence of single infestations 59 (15.4%) was higher than double 27 (7.1%) and triple 02 (0.52) infestations though the difference was not significant ($P>0.05$) (Table 4.13).

4.3.4 *Sex-related ectoparasite infestations of Streptopelia senegalensis*

A total of 231 males and 151 females birds were examined and the prevalence of ectoparasite on the male birds was 55 (23.8%) and 33 (21.9%) on the females. A total of 379 (56.7%) ectoparasites were recovered from 231 males examined while 289 (43.3%) were recovered from 151 females examined. Mean intensity in males was 6.9 ± 0.9 and 8.8 ± 0.9 in females (Table 4.13, 4.14, Appendix 2 and 4). Chi square test showed no significant association between sex and ectoparasite infestation ($P>0.05$).



Plate XXI: Anterior end of *Argas persicus* recovered from *S. senegalensis* and *T. abyssinicus* Mg X40

Table 4.11: Prevalence and predilection sites of ectoparasites on *Streptopelia senegalensis* in Zaria, Nigeria (n=382)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Columbicola columbae	37	9.7	307(46.0)	8.3±0.8	2-25	Quill feathers of wings and tail
Menopon gallinae	32	8.4	136(20.4)	4.3±0.4	1-10	Body, head and neck
Goniodes sp.	18	4.7	121(18.1)	6.7±1.1	1-15	Body, head and neck
Fly						
Pseudolynchia canariensis	19	5.0	46(6.9)	2.4±0.2	1-5	Down and Contour feathers of body
Tick						
Argas persicus	12	3.1	57(8.5)	4.8±0.8	1-10	Wing web and thigh
Mite						
Dermanyssus gallinae	1	0.3	1(0.2)	1.0±0.0	1-1	Legs
Total	88	23.0%	668(100.0)	7.6±0.4	1-25	Plumage

Table 4.12: Intensity of ectoparasite infestations on *S. senegalensis* in Zaria, Nigeria

Ectoparasites and frequency of intensity							
Class interval	*Columbicola Columbae*	*Menopon gallinae*	*Pseudolynchia Canariensis*	*Goniodes* sp.	*Argas persicus*	*Dermanyssus gallinae*	Total (%)
1-5	16	27	19	8	7	1	78(20.4)
6-10	8	5	0	7	5	0	25(6.5)
11-15	11	0	0	3	0	0	14(3.6)
16-20	1	0	0	0	0	0	1(0.3)
21-25	1	0	0	0	0	0	1(0.3)
Total	37 (9.7%)	32 (8.4%)	19 (5.0%)	18 (4.7%)	12 (3.1%)	1 (0.3%)	

Table 4.13: Frequency distribution of single and mixed ectoparasite infestations on *Streptopelia senegalensis* in Zaria, Nigeria

Infestation type	Parasite	Frequency of occurrence	
		Total	Percentage (%)
None		294	77.0
Single infestation	*Menopon gallinae*	18	
	Columbicola columbae	13	
	Pseudolynchia canariensis	12	
	Goniodes sp.	4	
	Argas persicus	12	
Sub total		59	15.4
Double infestation	*Menopon gallinae* + *Columbicola columbae*	8	
	Menopon gallinae + *Pseudolynchia canariensis*	5	
	Columbicola columbae + *Pseudolynchia canariensis*	1	
	Columbicola columbae + *Goniodes* sp.	13	
Sub total		27	7.1
Triple infestation	*M. gallinae* + *C. columbae* + *P. canariensis*	1	
	Goniodes sp. + *C. columbae* + *D. gallinae*	1	
Sub total		2	0.5
Grand total		88	23.0

Table 4.14: Prevalence and predilection sites of ectoparasites on male *Streptopelia senegalensis* in Zaria, Nigeria (n=231)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Columbicola columbae	21	9.1	186(49.1)	8.9±0.8	2-25	Quill feathers of wings and tail
Menopon gallinae	19	8.2	82(21.6)	4.3±0.4	1-10	Body, head and neck
Goniodes sp.	9	3.9	49(12.9)	5.4±1.0	1-15	Body, head and neck
Fly						
Pseudolynchia canariensis	12	5.2	26(6.9)	2.2±0.1	1-2	Down and contour feathers of body
Tick						
Argas persicus	8	3.5	35(9.2)	4.4±0.7	1-10	Wings web and thigh
Mite						
Dermanyssus gallinae	1	0.4	1(0.3)	1.0±0.0	1-1	Legs
Total	55	23.8	379(100.0)	6.9±0.9	1-25	Plumage

Table 4.15: Prevalence and predilection sites of ectoparasites on female *Streptopelia senegalensis* in Zaria, Nigeria (n=151)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Columbicola columbae	16	10.6	121(41.9)	7.6±1.5	2-20	Quill feathers of wings and tail
Menopon gallinae	13	8.6	54(18.7)	4.2±0.0	1-10	Body, head and neck
Goniodes sp.	9	6.0	72(24.9)	8.0±1.4	1-15	Body, head and neck
Fly						
Pseudolynchia canariensis	7	4.6	20(6.9)	2.9±0.4	1-2	Down and contour feathers of body
Tick						
Argas persicus	4	2.6	22(7.6)	5.5±1.2	1-10	Wings web and thigh
Total	33	21.9	289(100.0)	8.8±0.9	1-20	Plumage

4.3.5 *Effect of ectoparasite infestations on body weight and PCV*

The body weights and PCV values of infested and non-infested doves were within 40-115 g and 35-65% respectively and there was no significant difference between the mean body weights and mean PCV values of infested (81.3±2.4 g, 52±1.3 %) and uninfested (77.8±0.6 g, 53±0.3 %) doves (P>0.05).

4.3.6 *Monthly prevalence and intensity of ectoparasites*

The monthly prevalence of ectoparasites on *S. senegalensis* varied throughout the year, but the highest prevalence (60.0%) was in November (dry season) and lowest (5.0%) in December (dry season) (Figure 4.5). Overall prevalence in the wet season (23.5%) was higher than in the dry season (22.6%) but the difference was not significant (P>0.05). There was no association between ectoparasite infestations and the wet or dry season with ectoparasite infestation.

The highest mean monthly intensity was 15.0±2.6 in December and lowest was 2.0± 0.0 in February. Mean intensity in the wet season 8.4±0.7 was higher than 6.7 ± 0.3 in the dry season. A positive correlation was observed between ectoparasite infestation, rainfall and relative humidity (Appendix 21 and 22).

The monthly prevalence of each of the ectoparasite on *S. senegalensis* is presented in Figure 4.6, while the monthly prevalence, intensity and mean monthly intensity of individual ectoparasites on *S. senegalensis* are in Appendix 11.

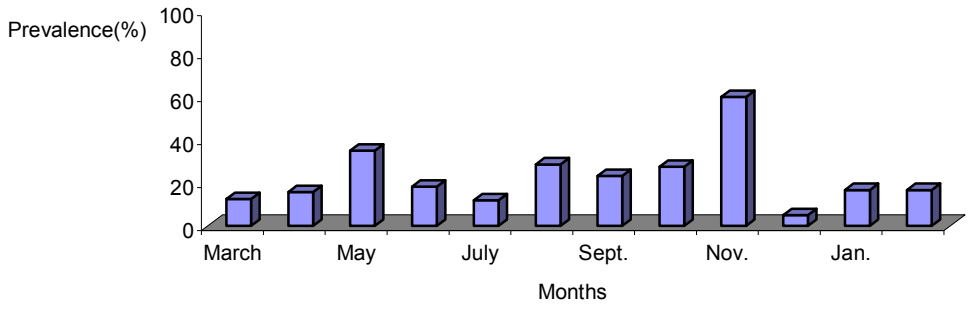


Figure 4.5: Total Monthly prevalence of ectoparasites on *S. senegalensis* in Zaria, Nigeria (2002 – 2004)

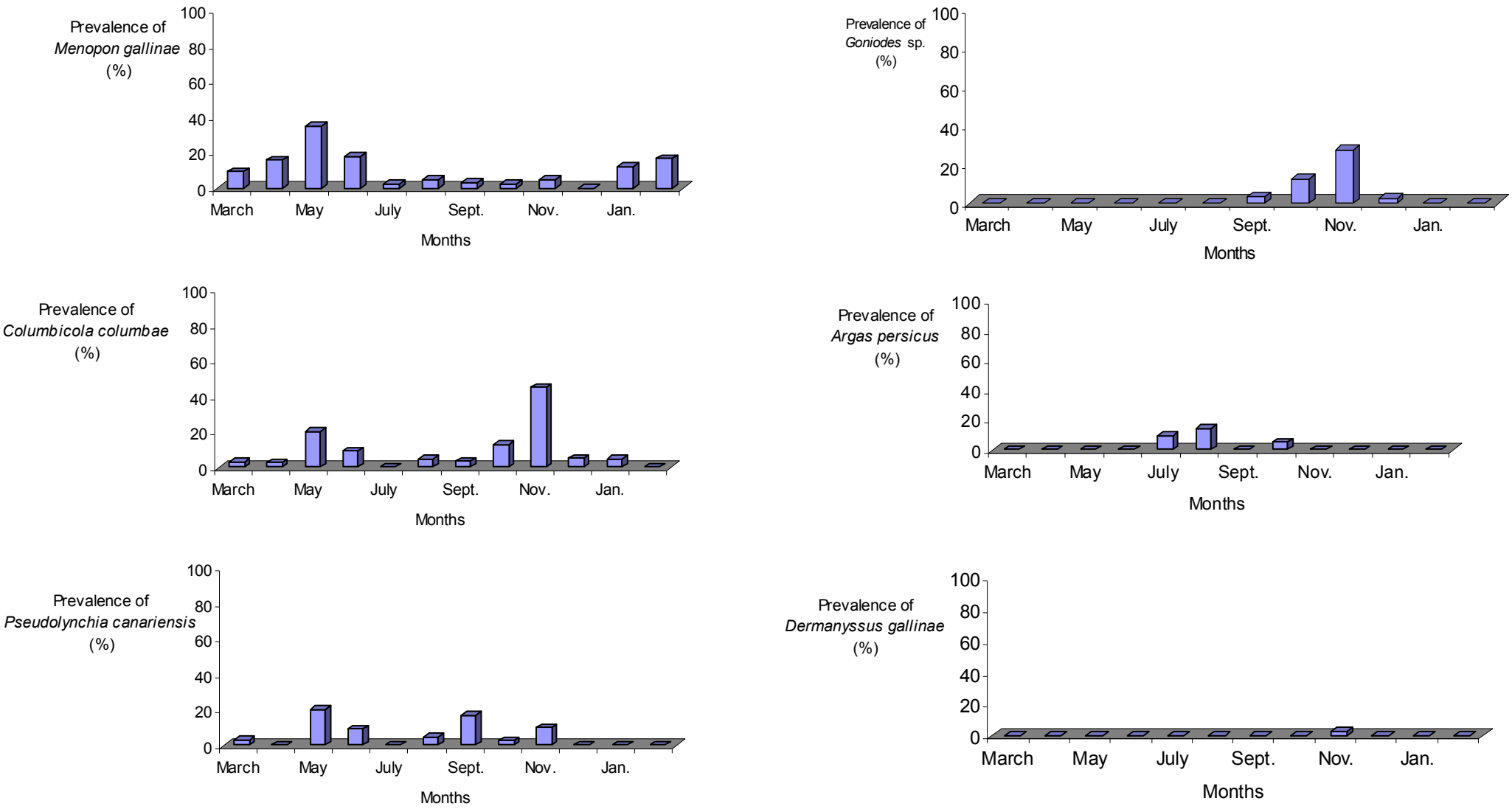


Figure 4. 6: Monthly prevalence of individual ectoparasites on *S. senegalensis* in Zaria, Nigeria

Menopon gallinae was recovered from the Columbids in all the months of the year except in December, with highest prevalence (35.0%) in May and lowest (2.4%) in July. The highest mean monthly intensity for *M. gallinae* was 6.3±0.6 in May and the lowest was 1.0±0.0 in October. *Columbicola columbae* was recovered from the birds in all the months except February and July, with highest prevalence (45.0%) in November and lowest (2.6%) in April. The highest mean monthly intensity for *C. columbae* was 16.2±1.3 in October and the lowest was 4.0+0.0 in March, September and January.

Pseudolynchia canariensis was recovered from the birds in seven months of the year, with highest prevalence (20.0%) in May and lowest (2.5%) in October. The highest mean monthly intensity for *P. canariensis* was 3.3+0.5 in May while the lowest was 2.0+0.0 in March, June, August, October and November.

Goniodes sp. was recovered from the Columbids in four months of the year with highest prevalence in November (27.5%) and lowest (2.5%) in December. The highest mean monthly intensity for *Goniodes* sp. was 13.0 ± 0.0 in December and lowest was 5.0 ± 0.0 in September.

Argas persicus was recovered in three months of the year with highest prevalence (14.3%) in August and lowest (5.0%) in October. The highest mean monthly intensity for *Argas persicus* was 6.5 ± 0.5 in October and the lowest was 3.2±0.6 in August.

Dermanyssus gallinae was only recovered in November with prevalence of 2.5% and mean intensity of 1.0 ± 0.0.

There were significant differences between the prevalence and mean monthly intensity of various ectoparasites (P<0.05).

4.4 **Helminths of *Streptopelia senegalensis***

4.4.1 *Prevalence of helminths*

Out of the 382 *S. senegalensis* examined, 221 (57.9%) were infected by helminths. Nine species of helminths were identified, including seven cestodes and two nematodes. Seventy-five (19.6%) of the birds were infected by *Raillietina tetragona*, 69 (18.1%) had *R. echinobothrida*, 11 (2.9%) had *R. magninumida*, 16 (4.2%) had *R. cesticillus*, 10 (2.6%) had *Amoebotaenia cuneata*, 28 (7.3%) had *Hymemolepis carioca*, 40 (10.5%) *H. cantaniana* had 2 (0.5%) had *Ascaridia galli*, and 3 (0.8%) *Heterakis gallinarum* (Plate XII-XVII, XIX, XX, XXII, Table 4. 15 and Appendix 5).

A total of 1838 parasites were rcovered and the relative abundance of the helminths were *R. tetragona* 798 (43.4%), *R. echinobothrida* 366 (19.7%), *R. magninumida* 103 (5.6%), *R. cesticillus* 24 (1.3%), *Amoebotaenia cuneata* 35 (1.9%), *Hymenolepis carioca* 304 (16.5%), *Hymenolepis cantaniana* 197 (10.7%), *Ascaridia galli* 3 (0.2%) and *Heterakis gallinarum* 8 (0.4%). The mean intensities of the helminths were *R. tetragona* 10.7 ± 1.2, *R. echinobothrida* 5.2 ± 0.7, *R. magninumida* 9.4 ± 3.1, *R. cesticillus* 1.5 ± 0.3, *Amoebotaenia cuneata* 3.5 ± 0.7, *Hymenolepis carioca* 10.9 ± 2.2, *H. cantaniana*

5.0 ± 0.6, *Ascaridia galli* 1.5 ± 0.5 and *Heterakis gallinarum* 2.7 ± 0.9. There were significant differences between the prevalence and mean intensity of the parasites. (P<0.05). The predilection sites of *R. tetragona*, *R. echinobothrida* and *H. cantaniana* were

in the duodenum and ileum, while *R*. *cesticillus* and *R*. *magninumida* were restricted to the ileum, *A*. *cuneata* and *H*. *carioca* were in the duodenum. The nematodes, *A*. *galli* and *Heterakis gallinarum* were restricted to the duodenum and caeca respectively (Table 4.15 and Appendix 7).



Plate XXII: Anterior end of *Raillietina magninumida* recovered from *S. senegalensis*, *S. decipiens* and *T. abyssinicus* Mg X40

Table 4.16: Prevalence and predilection sites of intestinal helminths in *S. senegalensis* in Zaria, Nigeria (n=382)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	75	19.6	798 (43.4)	10.6±1.2	1-46	Duodenum/ileum
Raillietina echinobothrida	69	18.1	366 (19.9)	5.3 ±0.7	1-21	Duodenum/ileum
Raillietina cesticillus	16	4.2	24 (1.3)	1.5±0.3	1- 5	Ileum
Raillietina magninumida	11	2.9	103 (5.6)	9.4±3.1	1-36	Ileum
Amoebotaenia cuneata	10	2.6	35 (1.9)	3.5±0.7	1- 8	Duodenum
Hymenolepis carioca	28	7.3	304 (16.5)	10.9±2.2	1-46	Duodenum
Hymenolepis cantaniana	40	10.5	197 (10.7)	5.0±0.6	1-16	Duodenum/ileum
Heterakis gallinarum	3	0.8	8 (0.4)	2.7±0.9	1- 2	Caeca
Ascaridia galli	2	0.5	3(0.2)	1.5±0.5	1- 2	Duodenum
Total	221	57.9	1838	8.3±0.5	1-46	Small intestine

4.4.2 *Intensity of helminth infections*

Table 4.16 shows the intensity of helminth infections in *S. senegalensis*. The number of individuals in the lower class intervals of 1-5, 6-10, 11-15, 16-20 and 21-25 (with low parasite burden) were more than those in the higher class intervals of 26-30, 31-35, 36-40, 41-45, 46-50 (with high parasite burden).

4.4.3 *Frequency distribution of single and mixed infections*

Single infections 191 (50.0%) were most prevalent than double 27 (7.1%) and triple infections 03 (0.8%) (Table 4.17).

4.4.4 *Sex-related helminth infetions of Streptopelia senegalensis*

A total of 231 males and 151 females were examined and helminth infections in the male birds was 128 (55.4%) and 93 (61.6%) in the females (Table 4. 18, 4.19, Appendix 6 and 8). A total of 1024 (55.7%) helminths were recovered from the males and 814 (44.3%) from the females and mean intensity was 8.0 ± 0.7 in males and 8.8 ± 3.9 in females. Chi-square test showed no significant association between sex and infection

($P > 0.05$).

Table 4. 17: Intensity of helminth infections in *S. senegalensis* in Zaria, Nigeria

	Helminths and frequency of intensity									
Class interval	*Raillietina tetragona*	*Raillietina echinobothrida*	*Raillietina Cesticillus*	*Raillietina magninumida*	*Amoebotaenia Cuneata*	*Hymenolepis carioca*	*Hymenolepis cantaniana*	*Heterakis gallinarum*	*Ascaridia galli*	Total (%)
1-5	32	47	16	7	8	15	27	3	2	157 (41.1)
6-10	17	14	0	1	2	2	8	0	0	44(11.5)
11-15	8	4	0	0	0	5	4	0	0	21(5.5)
16-20	5	3	0	1	0	1	1	0	0	11(2.9)
21-25	6	1	0	1	0	2	0	0	0	10(2.6)
26-30	2	0	0	0	0	1	0	0	0	3(0.8)
31-35	1	0	0	0	0	0	0	0	0	1(0.3)
36-40	1	0	0	1	0	0	0	0	0	2(0.5)
41-45	2	0	0	0	0	1	0	0	0	3(0.8)
46-50	1	0	0	0	0	1	0	0	0	2(0.5)
Total	75 (19.6%	69 (18.1%)	16 (4.2%)	11 (2.9%)	10 (2.6%)	28 (7.3%)	40 (10.5%)	3 (0.8%)	2 (0.5%)	

Table 4.18: Frequency distribution of single and mixed helminth parasite infections in *S. senegalensis* in Zaria, Nigeria

Infection Type	Parasite	Frequency of occurrence	
		Total	Percentage (%)
None		161	42.1
Single	*Raillietina tertragona*	55	
	Raillietina echinobothrida	60	
	Raillietina magninumida	11	
	Raillietina cesticillus	13	
	Amoebotaenia cuneata	7	
	Hymenolepis carioca	19	
	Hymenolepis cantaniana	24	
	Ascaridia galli	1	
	Heterakis gallinarum	1	
Total		191	50.0
Double	*Raillietina tertragona + Raillietina echinobothrida*		
	Raillietina tertragona + Amoebotaenia cuneata	3	
	Raillietina tetragona+ Hymenolepis carioca	2	
	Raillietina tetragona + Hymenolepis cantaniana	2	
	Raillietina tetragona+ Heterakis gallinarum	10	
	Raillitina echinobothrida + Hymenolepis carioca	1	
	Raillietina echinobothrida + H. cantaniana	2	
	Raillitina cesticillus+ Hymenolepis cantaniana	1	
	Raillietina cesticillus + Ascaridia galli	1	
	Raillietina cesticillus+ Heterakis gallinarum	1	
	Hymenolepis carioca + Hymenolepis cantaniana	1	
		3	
Total		27	7.1
Triple			
	R. tertragona +R. echinobothrida+ H. carioca	1	
	R. tetragona + R. echinobothrida H. cantaniana	1	
	R. echinobothrida + A. cuneata +H. carioca	1	
Total		3	0.8
Grand total		221	57.9

Table 4.19: Prevalence and predilection sites of intestinal helminths in male *S. senegalensis* in Zaria, Nigeria (n=231)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	46	19.9	529(51.3)	11.5±1.6	1-46	Duodenum/ileum
Raillietina echinobothrida	41	17.7	175(17.0)	4.3 ±0.5	1-21	Duodenum/ileum
Raillietina cesticillus	9	3.9	12 (1.2)	1.3±0.2	1- 5	Ileum
Raillietina magninumida	7	3.0	68 (6.6)	9.7±4.3	1-36	Ileum
Amoebotaenia cuneata	2	0.9	3 (0.3)	1.5±0.5	1- 8	Duodenum
Hymenolepis carioca	11	4.8	106 (10.3)	9.6±3.3	1-46	Duodenum
Hymenolepis cantaniana	25	10.8	121 (11.7)	4.8±0.9	1-16	Duodenum/ileum
Heterakis gallinarum	2	0.9	7(0.7)	3.5±0.5	1- 2	Caeca
Ascaridia galli	2	0.9	3 (0.3)	1.5±0.5	1- 2	Duodenum
Total	128	55.4	1024(100.0)	8.0±0.7	1-46	Small intestine

Table 4.20: Prevalence and predilection sites of intestinal helminths in female *S. senegalensis* in Zaria, Nigeria (n=151)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered(%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	29	19.2	269 (33.3)	9.3±1.8	1-45	Duodenum/ileum
Raillietina echinobothrida	28	18.5	191 (23.7)	6.8 ±1.1	1-20	Duodenum/ileum
Raillietina cesticillus	7	4.6	12 (1.5)	1.7±0.6	1- 5	Ileum
Raillietina magninumida	4	2.6	35 (4.3)	8.6±4.5	1-25	Ileum
Amoebotaenia cuneata	8	5.3	32 (4.0)	4.0±0.8	1- 8	Duodenum
Hymenolepis carioca	17	11.3	198 (24.5)	11.6±3.1	1-45	Duodenum
Hymenolepis cantaniana	15	9.9	76 (9.4)	5.1±1.0	1-15	Duodenum/ileum
Heterakis gallinarum	1	1.1	1 (0.1)	1.0±0.0	1- 1	Caeca
Total	93	61.6	814(100.0)	8.8±3.9	1-45	Small intestine

4.4.5 *Effect of helminth infections on body weight and PCV*

The body weights and PCV values of infected and non-infected doves were within 40-115 g and 35-65% respectively and there was no significant difference in the mean body weights and mean PCV values of infected (80.3±1.6 g, 54±1.1 %) and uninfected (78.0±0.8 g, 57±4.3 %) doves (P>0.05).

4.4.6 *Monthly prevalence and intensity of helminths*

Helminth parasites were recovered from the birds in all the months of the year with highest prevalence (83.3%) in August and lowest (27.5%) in November (Figure 4.7). Prevalence in the wet season (67.9%) was higher than in the dry season (47.3%). There was a marked association of infection with the wet season. The highest mean monthly intensity was 22.5±3.7 in May and the lowest was 2.5±0.2 in November. Mean monthly intensity in the wet season (10.2±0.4) was higher than (5.5. ±0.3) in the dry season. There was a positive correlation between helminth infection, rainfall and relative humidity (Appendix 21 and 22). The monthly prevalence of each helminth of *S. senegalensis* is presented on Figure 4.8, while the monthly prevalence, intensity and mean monthly intensity of individual helminths in *S. senegalensis* are presented in Appendix 12.

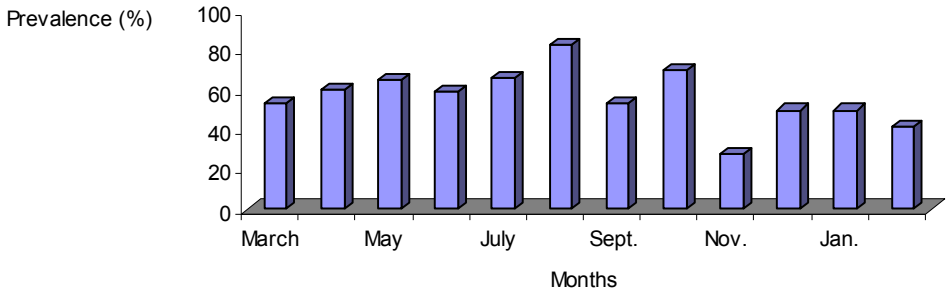


Figure 4.7: Total monthly prevalence of helminths of *Streptopelia senegalensis* in Zaria, Nigeria (2002 – 2004)

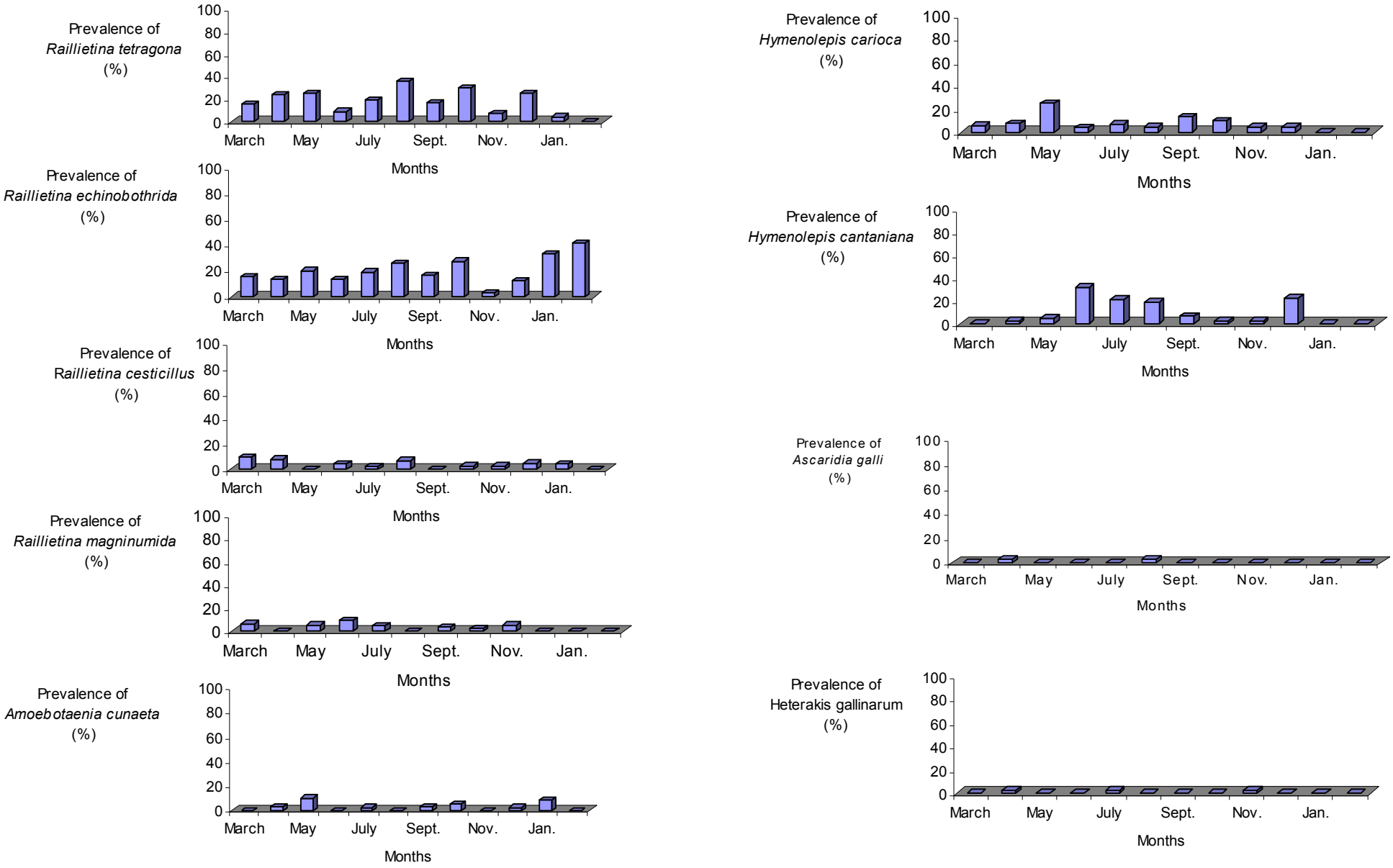


Figure 4.8: Monthly prevalence of individual helminths in *S. senegalensis* in Zaria, Nigeria

Raillietina tetragona was recovered in eleven months of the year, with highest prevalence (35.7%) in August and lowest (4.2%) in January. The highest mean monthly intensity was 22.2±8.2 in May and lowest was 1.0±0.0 in January. *Raillietina echinobothrida* was recovered in all the months of the year with highest prevalence (41.7%) in February and lowest (2.5%) in November. The highest mean monthly intensity was 17.5±3.5 in May and lowest was 2.6±1.0 in February. *Raillietina magninumida* was recovered in seven months of the year with highest prevalence (9.1%) in June and lowest (2.5%) in October. The highest mean monthly intensity was 36.0 ± 0.0 in May and the lowest was 1.0 ±0.0 in October. *Raillietina cesticillus* was recovered in nine months of the year, with highest prevalence (9.4%) in March and lowest (2.4%) in July. The highest mean monthly intensity was 2.7 ± 1.2 in August and the lowest was 1.0 ± 0.0 in March, April, July, November, December and January. *Amoebotaenia cuneata* was recovered in seven months of the year, with highest prevalence (10.0%) in May and lowest (2.4%) in July. The highest mean monthly intensity was 6.0 ± 2.0 in May while the lowest was 1.0± 0.0 in December. *Hymenolepis carioca* was recovered in ten months with highest prevalence (25.0%) in May and lowest prevalence (4.5%) in June. The highest mean monthly intensity was 23.0 ± 5.1 in December and the lowest was 1.0 ± 0.0 in June. *Hymenolepis cantaniana* was recovered in nine months with highest prevalence (31.8%) in June and lowest prevalence (2.4%) in April. The highest mean monthly intensity was 7.0 ± 0.0 in May and the lowest was 1.5 ± 0.5 in April.

Ascaridia galli was recovered in April and August. Prevalence in April was 2.6% and mean intensity was 2.0 ± 0.0 while prevalence in August was 2.4% mean intensity was 1.0±0.0.

Heterakis gallinarum was recovered in April, July and November, with prevalence of 2.6%, 2.4%, 2.4% and mean monthly intensity of 1.0± 0.0, 4.0 ± 0.0 and 3.0 ± 0.0 respectively.

4.5 **Ectoparasites of *Streptopelia decipiens***

4.5.1 *Prevalence of ectoparasites*

Out of the 48 *S. decipiens* examined, 26 (54.2%) were infested with ectoparasites, including two species of lice *Menopon gallinae* 20 (41.7%) and *Columbicola columbae* 15 (31.3%) and one species of fly *Pseudolynchia canariensis* 9 (18.8%) (Plates VII, VIII, X, Table 4.21 and Appendix 1).

A total of 369 parasites were recovered and the relative abundance of the ectoparasites were *Menopon gallinae* 160 (43.4%), *Columbicola columbae* 189 (51.2%) and *Pseudolynchia canariensis* 20 (5.4%). The mean intensities of the parasites were *Menopon gallinae* 8.0 ± 1.5, *Columbicola columbae* 12.6 ± 1.0 and *Pseudolynchia canariensis* 2.2 ± 0.2. *Menopon gallinae* was recovered from the head, neck and body, *C. columbae* from quill feathers of the wing and tail and *P. canariensis* from the down and contour feathers of the skin (Table 4. 21 and Appendix 3).

There were significant differences between the prevalence and mean intensity of the three ectoparasites ($P<0.05$).

4.5.2 *Intensity of ectoparasite infestations*

Table 4.22 shows the intensity of ectoparasite infestations on *S. decipiens.* The number of individuals in the lower class intervals of 1-5, 6-10 and 11-15 were more than those in the higher class intervals of 16-20 and 21-25.

4.5.3 *Frequency distribution of single and mixed infestations*

The prevalence of double infestations 12 (25.0%) was higher than single 11 (22.9%) and triple 3 (6.3%) infestations but the difference were not significant ($P>0.05$) (Table 4.23).

Table 4.21: Prevalence and predilection sites of ectoparasites on *Streptopelia decipiens* in Zaria, Nigeria (n=48)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice *Columbicola columbae*	15	31.3	189(51.2)	12.6±1.0	8-18	Quill feathers of wings and tail
Menopon gallinae	20	41.7	160(43.4)	8.0±1.5	2-24	Body, head and neck
Fly *Pseudolynchia canariensis*	9	18.8	20(5.4)	2.2±0.2	2-3	Down and contour feathers of body
Total	26	54.2	369(100.0)	14.2±0.9	2-24	Plumage

Table 4.22: Intensity of ectoparasite infestations on *S. decipiens* in Zaria, Nigeria

	Ectoparasites and frequency of intensity			
Class interval	*Columbicola Columbae*	*Menopon gallinae*	*Pseudolynchia Canariensis*	Total (%)
1-5	0	11	9	20 (41.7)
6-10	4	6	0	10 (20.8)
11-15	7	0	0	7 (14.6)
16-20	4	1	0	5 (10.4)
21-25	0	2	0	2 (4.2)
Total	15(31.3%)	20(41.7%)	9(18.8%)	

Table 4.23: Frequency distribution of single and mixed ectoparasite infestations on *Streptopelia decipiens* in Zaria, Nigeria

Infestation type	Parasite	Frequency of occurrence Total	Percentage (%)
None		22	45.8
Single	*Menopon gallinae*	7	
	Columbicola columbae	3	
	Pseudolynchia canariensis	1	
Total		11	22.9
Double	*Menopon gallinae* + *Columbicola columbae*	7	
	Menopon gallinae + *Pseudolynchia canariensis*	3	
	Columbicola columbae + *Pseudolynchia canariensis*	2	
Total		12	25.0
Triple	*M. gallinae* + *C. columbae* + *P. canariensi*	3	6.3
Grand total		26	54.2

4.5.4 *Sex-related ectoparasite infestations on Streptopelia decipiens*

A total of 30 males and 18 females were examined and ectoparasite infestation of the male birds was 15 (50.0%) and 11 (61.1%) in the females. A total of 151 (41.0%) ectoparasites was recovered from males and 218 (59.1%) from females. The mean intensity in males was 14.5 ± 1.3 and 13.7 ± 1.1 in females (Table 4.24, 4.25, Appendix 2 and 4). Chi square test showed no significant association between sex and infestation ($P>0.05$).

4.5.5 *Effects of ectoparasite infestations on body weight and PCV*

The body weights and PCV values of infested and non-infested doves were within 120-135 g and 35-65% respectively and there was no significant difference in the mean body weights and mean PCV of infested (169.8 ± 6.9g, 50 ± 2.6 %) and uninfested (160.5 ± 5.0g, 52.3 ± 0.9 %) doves ($P>0.05$).

4.5.6 *Monthly prevalence and intensity of ectoparasites*

Streptopelia decipiens was sampled in April, May, June and September, with ectoparasites recovered in all the four months. Highest prevalence was 80.0% in April and lowest was 37.5% in June. Odd ratio analysis showed association between April, May and September with ectoparasite infestation. The highest mean monthly intensity of ectoparasites was 20.1 ± 1.6 in May and lowest was 4.0 ± 2.6 in September.

The monthly prevalence of each ectoparasite of *S. decipiens* is presented in Figure 4.9, while the monthly prevalence, intensity and mean monthly intensity of individual ectoparasites on *S. decipiens* are presented in Appendix 13.

Table 4.24: Prevalence and predilection sites of ectoparasites on male *Streptopelia decipiens* in Zaria, Nigeria (n=30)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Columbicola columbae	8	26.7	107(49.1)	13.3±1.7	8-18	Quill feathers of wings and tail
Menopon gallinae	13	43.3	102(46.8)	7.8±1.9	2-24	Body, head and neck
Fly						
Pseudolynchia canariensis	4	13.3	9(4.1)	2.3±0.3	2-3	Down and contour feathers of body
Total	15	50.0	218(100.0)	14.5±1.3	2-24	Plumage

Table 4.25: Prevalence and predilection sites of ectoparasites on female *Streptopelia decipiens* in Zaria, Nigeria (n=18)

Parasite	Number of Columbids infested	Prevalence (%)	Total number recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Columbicola columbae	7	14.6	82(22.2)	1.7±1.0	8-18	Quill feathers of wings and tail
Menopon gallinae	7	14.6	58(15.7)	8.2±2.7	2-24	Body, head and neck
Fly						
Pseudolynchia canariensis	5	10.4	11(3.0)	2.2±0.2	2- 3	Down and contour feathers of body
Total	11	61.1	151(100.0)	13.7±1.1	2-24	Plumage

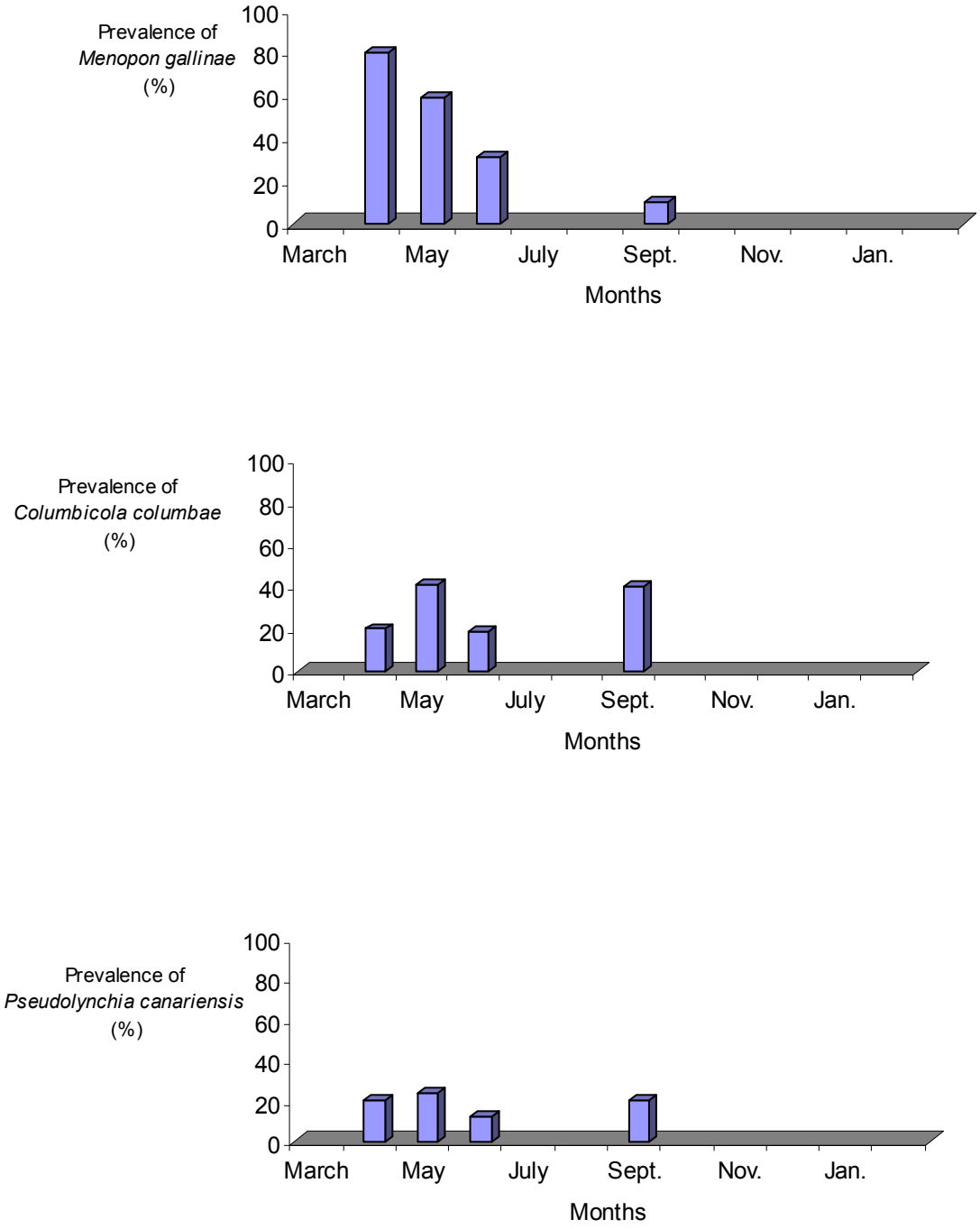


Figure 4.9: Monthly prevalence of individual ectoparasites on *S. decipiens* in Zaria, Nigeria

Menopon gallinae was recovered in all the four months sampled with highest prevalence (80.0%) in April and lowest (10.0%) in September. The highest mean monthly intensity for *M. gallinae* was 11.0 ± 2.7 in May and the lowest was 5.0 ± 0.0 in September.

Columbicola columbae was recovered in all the months sampled with highest prevalence (41.2%) in May and lowest (18.8%) in June. The highest mean monthly intensity for *C. columbae* was 16.0 ± 0.0 in April and lowest was 11.8 ± 1.4 in May and June.

Pseudolynchia canariensis was recovered in all the months sampled with highest prevalence (23.5%) in May and lowest (12.5%) in June. The highest mean monthly intensity for *P. canariensis* was 2.5±0.5 in June and September and lowest was 2.0±0.0 in April and May. There were significant differences between the monthly prevalence and mean monthly intensity of the three ectoparasites.

4.6 **Helminths of *Streptopelia decipiens***

4.6.1 *Prevalence of helminths*

Out of the 48 *S. decipiens* examined, 29 (60.4%) were found to harbour helminths. Six species of helminths, all cestodes were identified including. *R. tetragona* 12 (25.0%), *R. cesticillus* 6 (12.5%), *R. magninumida* 1 (2.1%), *Amoebotaenia cuneata* 8 (16.7%), *Hymenolepis carioca* 3 (6.3%) and *Hymenolepis cantaniana* 1 (2.1%) (Plates XII, XIV, XV, XVI, XVII, XXII, Table 4.26 and Appendix 5).

Table 4.26: Prevalence and predilection sites of intestinal helminths in *S. decipiens* in Zaria, Nigeria (n=48)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	12	25.0	90 (31.3)	7.5±1.8	2-26	Duodenum/ileum
Raillietina cesticillus	6	12.5	89 (30.9)	14.8±6.8	2-47	Duodenum/Ileum
Raillietina magninumida	1	2.1	22 (7.6)	22.0±0.0	1-22	Ileum
Amoebotaenia cuneata	8	16.7	47 (16.3)	5.9±2.0	1-19	Duodenum
Hymenolepis carioca	3	6.3	37 (12.8)	12.3±2.7	8-17	Duodenum
Hymenolepis cantaniana	1	2.1	3 (1.0)	3.0±0.0	1- 3	Ileum
Total	29	60.4	288(100.0)	9.9±1.7	1-47	Small intestine

A total of 288 parasites were recovered and the relative abundance of the parasites were *R. tetragona* 90 (31.3%), *R. cesticillus* 89 (30.9%), *R. magninumida* 22 (7.6%), *Amoebotaenia cuneata* 47 (16.3%), *H. carioca* 37 (12.8%) and *H. cantaniana* 3 (1.0%). The mean intensities of the helminths were: *R. tetragona* 7.5 ± 1.8, *R. cesticillus* 14.8 ± 6.8, *R. magninumida* 22.0 ± 0.0, *Amoebotaenia cuneata* 5.9 ± 2.0, *H. carioca* 12.3 ± 2.7 and *H. cantaniana* 3.0 ± 0.0.

There were statistically significant differences between the prevalence and mean intensity of the parasites ($P<0.05$). The predilection site of *R. tetragona* and *R. cesticillus* was the duodenum or ileum while *A. cuneata* and *H. carioca* was found in the duodenum and *R. magninumida* and *H. cantaniana* in the ileum (Table 4.26 and Appendix 7).

4.6.2 *Intensity of helminth infections*

Table 4.27 shows the intensity of helminth infections in *S. decipiens.* The number of individuals in the lower class intervals of 1-5, 6-10, 11-15, 16-20 and 21-25 (with low parasite burden) were more than those in the higher class intervals of 26-30, 31-35, 36-40, 41-45 and 46-50 (with high parasite burden).

4.6.3 *Frequency distribution of single and mixed infections*

Single infections was found in 27 (56.3%) and double in 2 (4.2%) (Table 4.28).

4.6.4 *Sex-related helminth infections of S. decipiens*

A total of 30 males and 18 females were examined and helminth infection in the male birds was 21 (70.0%) and 8 (44.4%) in the females. A total of 234 (81.3%) helminths was

recovered from males with mean intensity of 11.1 ± 2.2 while a total of only 54 (18.8%) was recovered from females with mean intensity of 6.8±1.1 (Table 4. 29, 4.30, Appendix 6 and 8). There was no sex-related difference between the prevalence of the helminths ($P<0.05$).

4.6.5 *Effect of helminth infections on body weight and PCV*

The body weights and PCV of infected and non-infected doves were between 120-135 g and 35-65% respectively and there was no significant difference in the mean body weights and mean PCV values of infected (146.8±6.9 g, 52±1.7 %) and uninfected (163.1±4.5 g, 49.6±2.7 %) doves ($P>0.05$).

4.6.6 *Monthly prevalence and intensity of helminths*

Streptopelia decipiens was sampled in April, May, June and September. Helminths were recovered in all the months with highest prevalence (76.5%) in May and lowest in (40.0%) in September. The highest mean monthly intensity was 13.2 ± 3.4 in May and the lowest was 2.7±0.7 in April. The monthly prevalence of each helminth of *S. decipiens* is presented in Figure 4.10, while the monthly prevalence, intensity and mean monthly intensity of individual helminths in *S. decipiens* are presented in Appendix 14.

Table 4.27: Intensity of helminth infections in *S. decipiens* in Zaria, Nigeria

Helminths and frequency of intensity							
Class interval	*Raillietina tetragona*	*Raillietina Cesticillus*	*Raillietina magninumida*	*Amoebotaenia Cuneata*	*Hymenolepis carioca*	*Hymenolepis cantaniana*	Total (%)
1-5	5	1	0	6	0	1	13(27.1)
6-10	6	2	0	1	1	0	10(20.8)
11-15	0	2	0	0	1	0	3(6.3)
16-20	0	0	0	1	1	0	2(4.2)
21-25	0	0	1	0	0	0	1(2.1)
26-30	1	0	0	0	0	0	1(2.1)
31-35	0	0	0	0	0	0	0(00)
36-40	0	0	0	0	0	0	0(00)
41-45	0	0	0	0	0	0	0(00)
46-50	0	1	0	0	0	0	1(2.1)
Total	12 (25.0%)	6 (12.5%)	1 (2.1%)	8 (16.7%)	3 (6.3%)	1 (2.1%)	

Table 4.28: Frequency distribution of single and mixed helminth infections in *S. decipiens* in Zaria

Infection type	Parasite	Frequency of occurrence Total	Percentage (%)
None		19	39.6
Single	*Raillietina tertragona*	10	
	Raillietina cesticillus	5	
	Raillietina magninumida	1	
	Amoebotaenia cuneata	8	
	Hymenolepis carioca	2	
	Hymenolepis camtaniana	1	
Total		27	56.3
Double	*Raillietina tertragona* + *Raillietina cesticillus*	1	
	Raillietina tetragona+ *Hymenolepis carioca*	1	
Total		2	4.2
Grand total		29	60.4

Table 4.29: Prevalence and predilection sites of intestinal helminths in male *S. decipiens* in Zaria, Nigeria (n=30)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	8	26.7	63 (26.9)	7.9±3.0	2-26	Duodenum/ileum
Raillietina cesticillus	5	16.7	78 (33.3)	15.6±9.3	2-47	Duodenum/Ileum
Raillietina magninumida	1	3.3	22 (9.4)	22±0.0	1-22	Ileum
Amoebotaenia cuneata	6	20.0	39 (6.7)	6.5±2.7	1-19	Duodenum
Hymenolepis carioca	2	6.7	29 (12.4)	14.5±5.4	8-17	Duodenum
Hymenolepis cantaniana	1	3.3	3 (1.3)	3.0±0.0	1- 3	Ileum
Total	21	70.0	234(81.3)	11.1±2.2	1-47	Small intestine

Table 4.30: Prevalence and predilection sites of intestinal helminths in female *S. decipiens* in Zaria, Nigeria (n=18)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	4	22.2	27 (50.0)	6.8±1.7	2-10	Duodenum/ileum
Raillietina cesticillus	1	5.6	11 (20.4)	11.0±0.0	2-15	Duodenum/Ileum
Amoebotaenia cuneata	2	11.1	8 (14.8)	4.0±0.0	1-9	Duodenum
Hymenolepis carioca	1	5.6	8 (14.8)	8.0±0.0	1-8	Duodenum
Total	8	44.4	54(100.0)	6.8±1.1	1-15	Small intestine

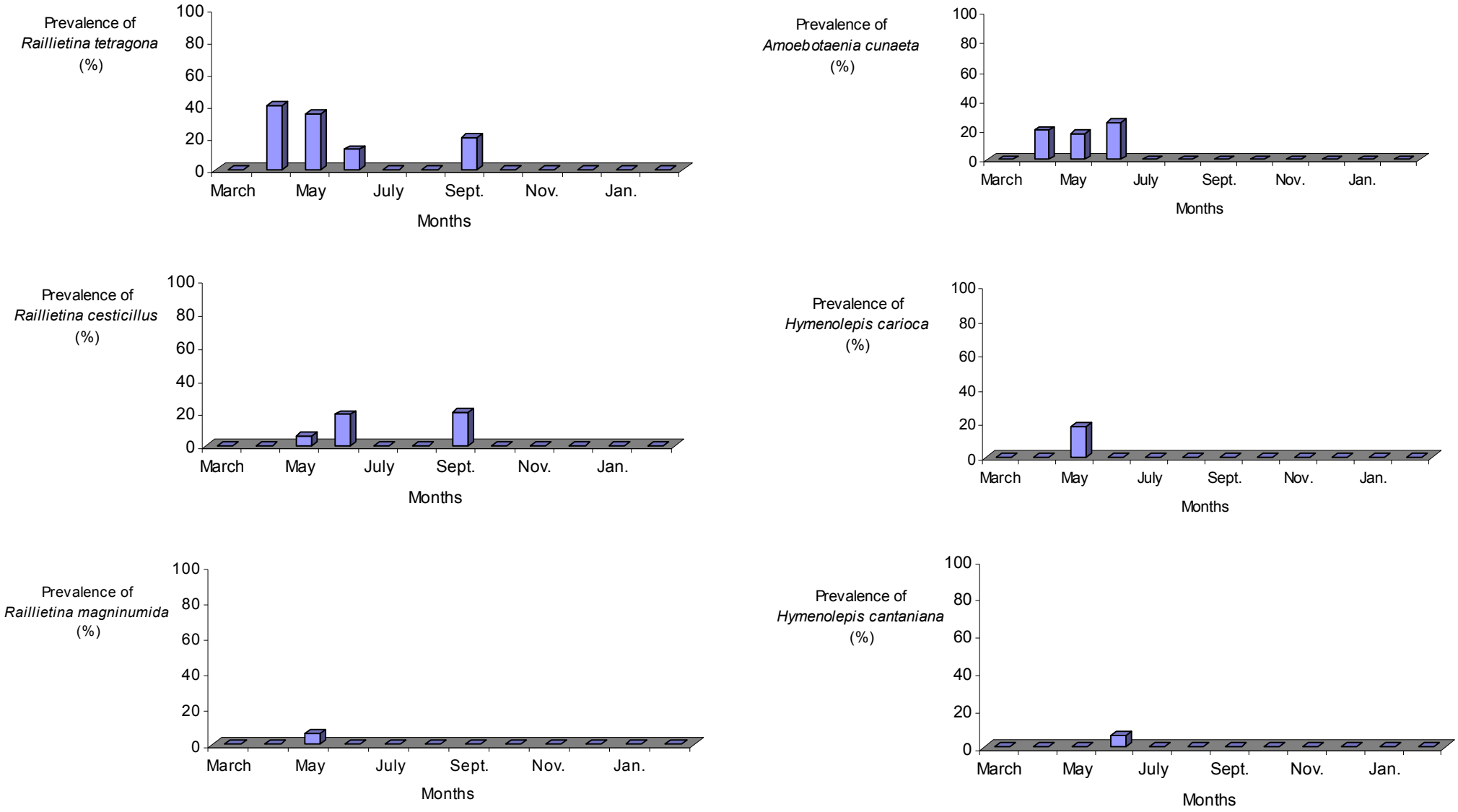


Figure 4.10: Monthly prevalence of individual helminths in *S. decipiens* in Zaria, Nigeria

Raillietina tetragona was recovered in all the months from the birds, with highest prevalence (40.0%) in April and lowest (12.5%) in June. The highest mean monthly intensity was 17.0 ± 9.1 in June and the lowest was 2.0 ± 0.0 in April. *Raillietina cesticillus* was recovered in three months with highest prevalence (20.0%) in September and lowest (5.9%) in May. The highest mean monthly intensity was 47.0 ± 0.0 in May and the lowest was 6.3 ± 2.7 in June. *Raillietina magninumida* was recovered only in May with a prevalence of 5.9% and mean intensity of 22.0 ± 0.0. *Amoebotaenaia cuneata* was recovered in April, May and June with highest prevalence (25.0%) in June and lowest (17.6%) in May. The highest mean monthly intensity was 10.3 ± 4.5 in May and lowest was 3.0 ± 0.9 in June. *Hymenolepis carioca* was recovered only in May with prevalence of 17.6% and mean intensity of 12.3 ± 3.3. *Hymenolepis cantaniana* was recovered only in June with a prevalence of 6.3% and mean intensity of 3.0 ± 0.0.

4.7 **Ectoparasites of *Columba guinea***

4.7.1 *Prevalence of ectoparasites*

Out of the 28 *Columba guinea* examined, 18 (64.3%) were infested by ectoparasites. Two species of lice were identified including *Menopon gallinae* in 17 (60.7%) and *Columbicola columbae* in 18 (64.3%). One species of fly *Pseudolynchia canariensis* 9 (32.1%) was also identified (Plates VII, VIII, X, Table 4.31 and Appendix 1).

A total of 563 parasites were recovered and the relative abundance of the parasites were *Menopon gallinae* 161(28.6%), *Columbicola columbae* 375 (66.6%) and *Pseudolynchia canariensis* 27 (4.8%).

The mean intensities of the parasites were *Menopon gallinae* 9.5 ± 2.0, *Columbicola columbae* 20.8 ± 2.2 and *Pseudolynchia canariensis* 3.0 ± 0.7. *Menopon gallinae* was recovered from the head, neck and body, *C. columbae* from quill feathers of the wing and tail and *P. canariensis* from the down and contour feathers of the skin (Table 4.31 and Appendix 3). There were significant differences between the prevalence and mean intensity of the three ectoparasites ($P<0.05$).

4.8.2 *Intensity of ectoparasite infestations*

Table 4.32 shows the intensity of ectoparasite infestations on *C. guinea* in Zaria. The number of individuals in the lower class intervals of 1-5, 6-10, 11-15, 16-20, 21-25 and 26-30 (with low parasite burden) were more than those in the higher class intervals of 31-35, 36-40, 41-45 and 46-50 (with high parasite burden).

4.8.3 *Frequency distribution of single and mixed infestations*

The prevalence of triple infestations 09 (32.1%) was higher than double 08 (28.6) and single 01 (3.6%) infestations and the difference was significant ($P< 0.05$) (Table 4.33).

4.8.4 *Sex-related ectoparasite infestations of Columba guinea*

A total of 20 males and 8 females were examined and the prevalence of ectoparasites in the male birds was 12 (60.0%) and 6 (75.0%) in the females. A total of 403 (71.6%) ectoparasites were recovered from males and 160 (28.4%) from females. The mean intensity in males was 33.3 ± 2.2 and 26.7 ± 2.0 in females (Table 4.34, 4.35, Appendix 2 and 4). Chi square test showed no significant association between sex and infestation ($P>0.05$).

Table 4.31: Prevalence and predilection sites of ectoparasites on *Columba guinea* in Zaria, Nigeria (n=28)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Columbicola columbae	18	64.3	375(66.6)	20.8±2.19	9-28	Quill feathers of wings and tail
Menopon gallinae	17	60.7	161(28.6)	9.5±2.04	3-34	Body, head and neck
Fly						
Pseudolynchia canariensis	9	32.1	27(4.8)	3.0±0.67	2-8	Down and contour feathers of body
Total	18	64.3	563(100.0)	31.3±1.06	2-34	Plumage

Table 4.32: Intensity of ectoparasite infestations on *C. guinea* in Zaria, Nigeria

	Ectoparasites and frequency of intensity			
Class interval	*Columbicola columbae*	*Menopon Gallinae*	*Pseudolynchia Canariensis*	Total (%)
1-5	0	9	8	17(60.7))
6-10	1	2	1	4(14.3)
11-15	4	3	0	7(25.0)
16-20	4	2	0	6(21.4)
21-25	4	0	0	4(14.3)
26-30	4	0	0	4(4.3)
31-35	0	1	0	1(3.6)
36-40	0	0	0	0(0.0)
41-45	0	0	0	0(0.0)
46-50	1	0	0	1(3.6)
Total	18(64.3%)	17(60.7%)	9(32.1))	

Table 4.33: Frequency distribution of single and mixed ectoparasite infestations on *Columba guinea* in Zaria, Nigeria

	Parasite	Frequency of occurrence	
		Total	Percentage (%)
None		10	35.7
Single			
	Columbicola columbae	1	3.6
Double			
	Menopon gallinae + *Columbicola columbae*	8	28.6
Triple			
	M. gallinae + *C. columbae* + *P. canariensis*	9	32.1
Total		18	64.3

Table 4.34: Prevalence and predilection sites of ectoparasites on male *Columba guinea* in Zaria, Nigeria (n=20)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Columbicola columbae	12	60.0	268(66.5)	22.3 ±2.9	9-48	Quill feathers of wings and tail
Menopon gallinae	11	55.0	117(29.0)	10.6 ±3.0	3-34	Body, head and neck
Fly						
Pseudolynchia canariensis	6	30.0	18(4.5)	3.0 ±1.0	2-8	Down and contour feathers of body
Total	12	60.0	403(100.0)	33.6±2.2	2-48	Plumage

Table 4.35: Prevalence and predilection sites of ectoparasites on female *Columba guinea* in Zaria, Nigeria (n=8)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Columbicola columbae	6	75.0	107(66.9)	17.8±2.7	11-28	Quill feathers of wings and tail
Menopon gallinae	6	75.0	44(27.5)	7.3±2.	3-34	Body, head and neck
Fly						
Pseudolynchia canariensis	3	37.5	9(5.6)	3.0±0.6	2-5	Down and contour feathers of body
Total	6	75.0	160(100.0)	26.7±2.0	2-34	Plumage

4.7.5 *Effect of ectoparasite infestations on body weight and PCV*

The body weights and PCV values of infected and non-infected pigeons were between 220-550 g and 35-65% respectively and there was no significant difference in the mean body weights and mean PCV values of infected (266.9±7.11 g, 51±1.3 %) and uninfected (265.5±9.4 g, 45±1.3 %) pigeons (P>0.05).

4.7.6 *Monthly prevalence and intensity of ectoparasites*

Columba guinea was sampled only in the months of March, April, May, June and February. Ectoparasites were recovered from the birds in four of the five months in which birds were sampled. The highest prevalence of 100.0% was recorded in the birds in April, May and June and 33.3% prevalence in February and there was no infestation of birds in March. The highest mean monthly intensity of ectoparasites was 47.5±3.2 in June and lowest was 20.8±1.9 in May.

The monthly prevalence of each ectoparasite of *C. guinea* is presented on Figure 4.11, while the monthly prevalence, intensity and mean monthly intensity of individual ectoparasites on *C. guinea* are presented in Appendix 15.

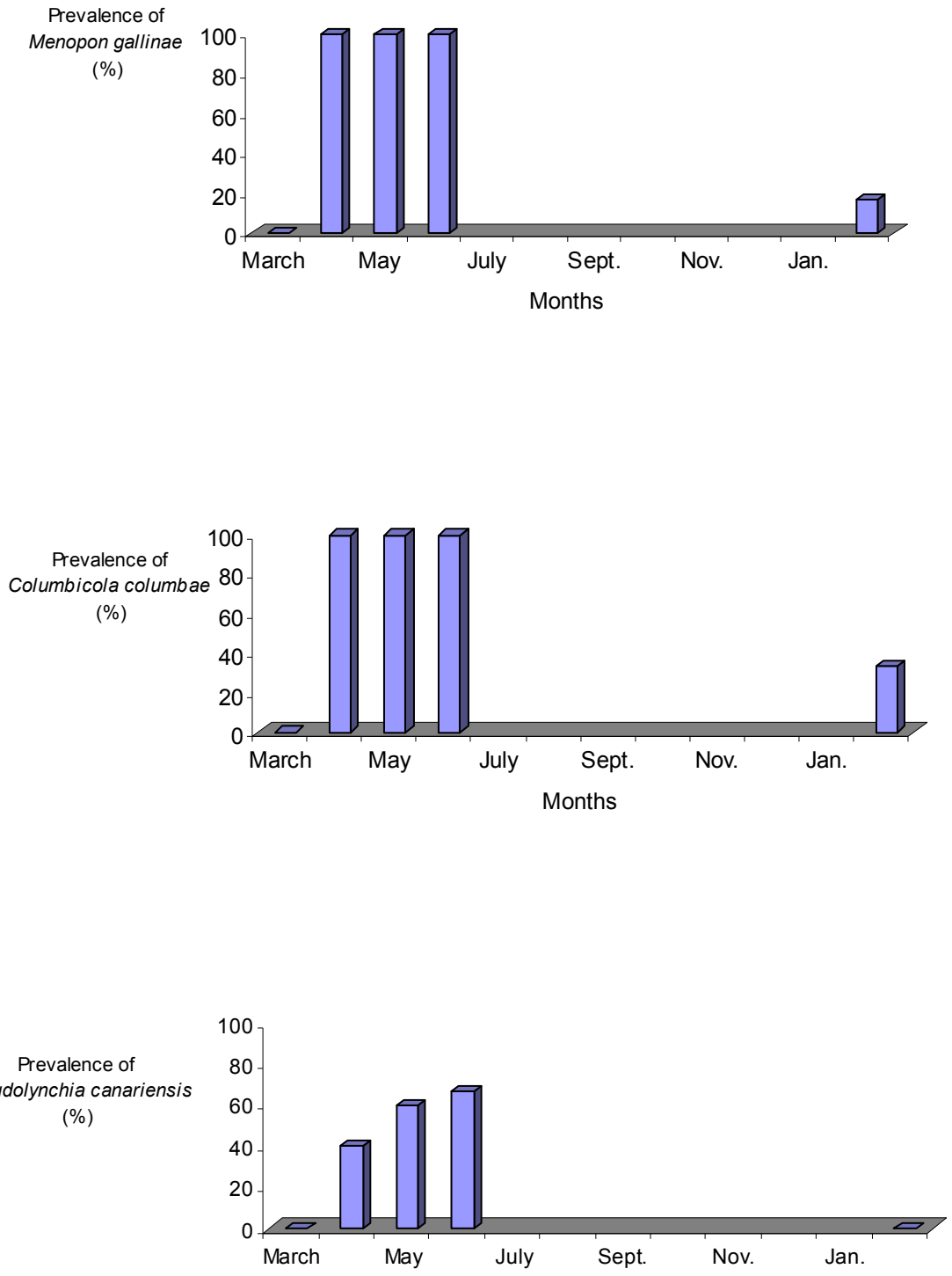


Figure 4.11: Monthly prevalence of individual ectoparasites on *C. guinea* in Zaria, Nigeria

Menopon gallinae was recovered in April, May, June and February with 100.0% prevalence in April, May and June and 16.7% in February. The highest mean monthly intensity was 17.0 ± 4.0 in June and the lowest was 4.2 ± 0.2 in April and May.

Columbicola columbae was recovered in three of the months in which sampling was carried out with 100.0% prevalence in April, May and June and 33.3% in February. The highest mean monthly intensity was 27.8 ± 4.5 in June and lowest was 13.0 ± 1.0 in February.

Pseudolynchia canariensis was recovered in four of the months sampled with highest prevalence 66.7% in June and lowest prevalence 40.0% in April. The highest mean monthly intensity was 4.0 ± 1.4 in June and the lowest was 2.0 + 0.0 in May.

Chi square analysis showed association between the three ectoparasites with the wet months. There were no significant differences in prevalence and mean monthly intensity of the three ectoparasites between months (P>0.05).

4.8 **Helminths of *Columba guinea***

4.8.1 *Prevalence of helminths*

Of the 28 *Columba guinea* examined, 17 (60.7%) were found to harbour helminths. Four species of helminths (all cestodes) were identified and these included *R. tetragona* in 1(3.6%), *R. cesticillus* in 8 (28.6%), *Amoebotaenia cuneata* in 4 (14.3%) and *Hymenolepis carioca* in 4 (14.3%) (Plates XII, XIV, XV, XVI, Table 4.36 and Appendix 5).

Table 4.36: Prevalence and predilection sites of intestinal helminths in *Columba guinea* in Zaria, Nigeria (n=28)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	1	3.6	16 (14.7)	16.0±0.0	1-16	Ileum
Raillietina cesticillus	8	28.6	40 (36.7)	5.0±2.2	1-17	Ileum
Amoebotaenia cuneata	4	14.3	13 (11.9)	3.2±0.9	2-6	Duodenum/Ileum
Hymenolepis carioca	4	14.3	40 (36.7)	10.0±4.6	3-22	Duodenum
Total	17	60.7	109(100.0)	6.4±1.6	1-22	Small intestine

A total of 109 parasites were recovered and the relative abundance of the helminths were *R. tetragona* 16 (14.7%), *R. cesticillus* 40 (36.7%), *Amoebotaenia cuneata* 13 (11.9%) and *Hymenolepis carioca* 40 (36.7%). The mean intensities of the helminths were as follows *R. tetragona* 16.0 ± 0.0, *R. cesticillus* 5.0 ± 2.2, *Amoebotaenia cuneata* 3.2 ± 0.9 and *Hymenolepis carioca* 10.0 ± 4.6 (Table 4.36 and Appendix 7).

There were statistically significant differences between the prevalence and mean intensity of the parasites ($P<0.05$). The predilection site of *R. tetragona* and *R. cesticilus* was the ileum while for *A. cuneata* it was the duodenum and ileum and for *H. carioca* the duodenum.

4.8.2 *Intensity of helminth infections*

Table 4.37 shows the intensity of helminth infections in *C.guinea*. The number of individuals in the lower class intervals of 1-5, 6-10 and 11-15 (with low parasite burden) were more than those in the higher class intervals of 16-20 and 21-25 (with high parasite burden).

4.8.3 *Frequency distribution of single and mixed infections*

Single infection was the only infection type observed (Table 4. 38). Single infection was recorded for the following parasites, *Raillietina tetragona*, *R. cesticillus*, *Amoebotaenia cuneata* and *Hymenolepis carioca*. These parasites accounted for 60.7% of infection.

4.8.4 *Sex-related helminth infections of Columba guinea*

A total of 20 males and 8 females were examined and helminth infection in the male birds was 11 (55.0%) and 6 (75.0%) in the females.

A total of 71 (65.1%) helminths was recovered from the males and 38 (34.9%) from the females. The mean intensity in males was 6.5 ± 2.4 and 6.3 ± 1.9 in females (Table 4. 39, 4. 40, Appendix 6 and 8). Chi-square analysis showed no association between sex and infection ($P>0.05$).

Table 4.37: Intensity of helminth infections in *C. guinea* in Zaria, Nigeria

Helminths and frequency of intensity					
Class interval	*Raillietina tetragona*	*Raillietina Cesticillus*	*Amoebotaenia Cuneata*	*Hymenolepis carioca*	Total (%)
1-5	0	6	3	2	11(39.3)
6-10	0	0	1	0	1(3.6)
11-15	0	1	0	1	2(7.1)
16-20	1	1	0	0	2(7.1)
21-25	0	0	0	1	1(3.6)
Total	1(3.6)	8(28.6)	4(14.3)	4(14.3)	

Table 4.38: Frequency distribution of single and mixed helminth infections in *C. guinea* in Zaria, Nigeria

Infection type	Parasite	Frequency of occurrence Total	Percentage (%)
None	No infection	11	39.3
Single			
	Raillietina tertragona	1	
	Raillietina cesticillus	8	
	Amoebotaenia cuneata	4	
	Hymenolepis carioca	4	
	Total	17	60.7

Table 4.39: Prevalence and predilection sites in intestinal helminths of male *Columba guinea* in Zaria, Nigeria (n=20)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	1	5.0	16 (22.5)	16.0±0.0	1-15	Ileum
Raillietina cesticillus	6	30.0	23 (32.4)	3.8±2.7	1-17	Ileum
Amoebotaenia cuneata	3	15.0	10 (14.1)	3.3±1.4	2-6	Duodenum/Ileum
Hymenolepis carioca	1	5.0	22(31.0)	22.0±0.0	3-22	Duodenum
Total	11	55.0	71(65.1)	6.5±2.4	1-22	Small intestine

Table 4.40: Prevalence and predilection sites of intestinal helminths in female *Columba guinea* in Zaria, Nigeria (n=8)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina cesticillus	2	25.0	17 (44.7)	8.5±3.5	1-15	Ileum
Amoebotaenia cuneata	1	12.5	3 (7.9)	3.0±0.0	1-3	Ileum
Hymenolepis carioca	3	37.5	18 (47.4)	6.0±6.5	1-15	Duodenum/Ileum
Total	6	75.0	38 (34.9)	6.3±1.9	1-15	Small intestine

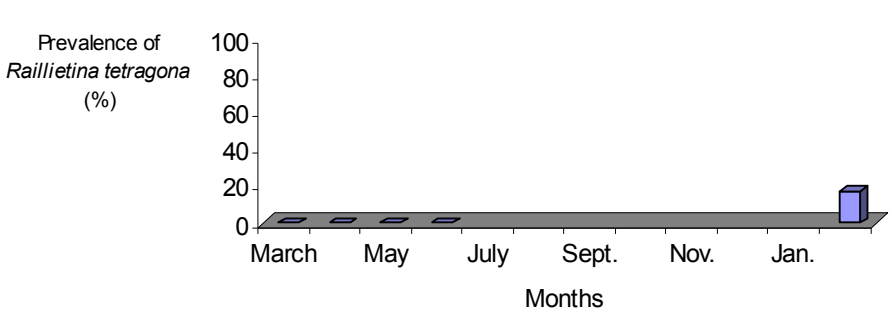
4.8.5 *Effect of helminth infections on body weight and PCV*

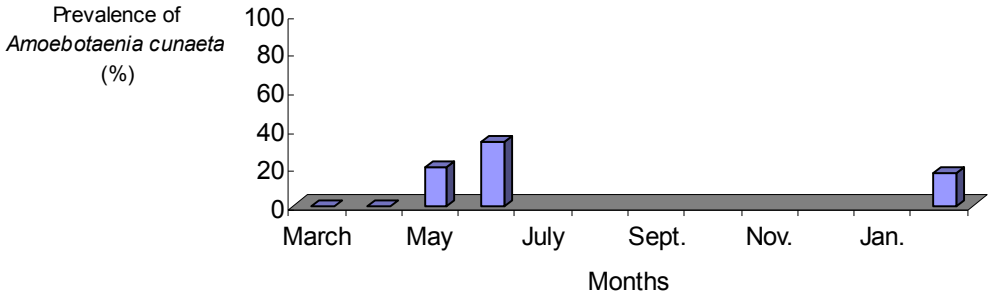
The body weights and PCV values of infected and non-infected pigeons were between 220-550 g and 35-65% respectively and there was no significant difference between the mean body weights and mean PCV values of infected (267.6±9.4 g, 52±1.3 %) and uninfected (272.7 ±8.5 g, 50±1.6 %) pigeons (P>0.05).

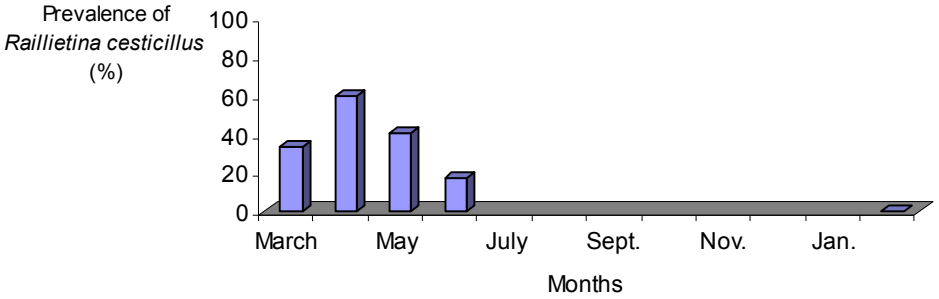
4.8.6 *Monthly prevalence and intensity of helminths*

Columba guinea was sampled in March, April, May, June and February. Helminths were recovered in all the months with highest prevalence (83.3%) in June and lowest (33.3%) in March and February. The highest mean monthly intensity was 14.5 ± 2.5 in March and the lowest was 2.5 ± 1.0 in April.

The monthly prevalence of each helminth of *C. guinea* is presented in Figure 4.12, while the monthly prevalence, intensity and mean monthly intensity of individual helminths on *C. guinea* are presented in Appendix 16.







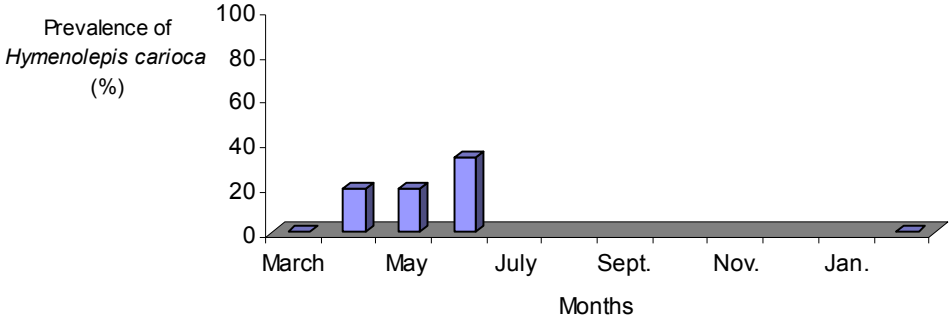


Figure 4.12: Monthly prevalence of individual helminths in *C. guinea* in Zaria, Nigeria

Railletina tetragona was recovered only in February with a prevalence of 16.7% and mean monthly intensity of 16.0±0.0. *Raillietina cesticillus* was recovered in four months with the highest prevalence (60.0%) in April and lowest (16.7%) in June. The highest mean monthly intensity was 14.5±2.5 in March and lowest 1.0±0.0 in June. *Amoebotaemia cuneata* was recovered in May, June and February with highest prevalence (33.3%) in June and lowest (16.7%) in February. The highest mean monthly intensity was 6.0±0.0 in May and the lowest was 2.0±0.0 in February. *Hymenolepis carioca* was recovered in April, May and June, with highest prevalence (33.3%) in June and lowest (20.0%) in April and May. The highest mean monthly intensity was 17.0± 0.6 in June and the lowest was 3.0±0.0 in April and May.

4.9 **Ectoparasites of *Turtur abyssinicus***

4.9.1 *Prevalence of ectoparasites*

Of the 32 *Turtur abyssinicus* examined, 7 (21.9%) were infected by ectoparasites including two species of lice *Menopon gallinae* 1 (3.1%) and *Columbicola columbae* 5 (15.6%) and one species of tick *Argas persicus* 2 (6.3%) were identified (Plates VII, VIII, XXI, Table 4.41 and Appendix 1).

A total of 65 parasites were recovered and the relative abundance of the parasites were *Menopon gallinae* 2 (3.1%), *Columbicola columbae* 60 (92.3%) and *Argas persicus* 3 (4.6%). The mean intensity of the parasites were *Menopon gallinae* 2.0 ± 0.0, *Columbicola columbae* 12.0±4.6 and *Argas persicus* 1.5 ± 0.5.

Menopon gallinae were recovered from the head, neck and body, *C. columbae* from quill feathers of the wing and tail and *Argas persicus* from the wing web (Table 4.41 and Appendix 3).

There were significant differences between the prevalence and mean intensity of the three ectoparasites ($P<0.05$).

4.9.2 *Intensity of ectoparasite infestations*

Table 4.42 shows the intensity of ectoparasite nifestations on *Turtur abyssinicus* in Zaria. The number of individuals in the lower class intervals of 1-5 and 6-10 (with low parasite burden) were more than those in the higher class interval of 11-15 (with high parasite burden).

4.9.3 *Frequency distribution of single and mixed infestations*

The prevalence of single infestations 6 (18.8%) was higher than double infestations 1 (3.1%) and the difference was significant ($P<0.05$) (Table 4.43).

4.9.4 *Sex-related ectoparasite infestations of Turtur abyssinicus*

A total of 20 males and 12 females were examined and five (25.0%) of the males were infested by ectoparasites while only 2 (16.7%) of the females had ectoparasites. A total of 59 (90.8%) ectoparasites was recovered from the males and 6 (9.2%) from the females. The mean intensity of the parasites in males was 11.8 ± 4.3 and 3.0 ± 1.0 in females. Chi square test showed no significant association between sex and infestation ($P>0.05$) (Table 4.44, 4.45, Appendix 2 and 4).

Table 4.41: Prevalence and predilection sites of ectoparasite on *Turtur abyssinicus* in Zaria, Nigeria (n=32)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ± SE	Range	Site of recovery
Lice						
Columbicola columbae	5	15.6	60 (92.3)	2.0±4.6	4-14	Quill feathers of wings and tail.
Menopon gallinae	1	3.1	2 (3.1)	2.0±0.0	1- 2	Body, head and neck
Tick						
Argas persicus	2	6.3	3 (4.6)	1.5±0.5	1- 2	Wing web
Total	7	21.9	65 (100.0)	9.3±3.3	1-14	Plumage

Table 4.42: Intensity of ectoparasite infestations on *Turtur abyssinicus* in Zaria, Nigeria

	Ectoparasites and frequency of intensity			
Class interval	*Columbicola columbae*	*Menopon Gallinae*	*Argas persicus*	Total (%)
1-5	2	1	2	5 (15.6)
6-10	1	0	0	1 (3.1)
11-15	2	0	0	2 (6.3%)
Total	5(15.6%)	1(3.1%)	2(6.3%)	

Table 4.43: Frequency distribution single and mixed ectoparasite infestations on *Turtur abyssinicus* in Zaria, Nigeria

	Parasite	Frequency of occurrence Total	Percentage (%)
None		25	78.1
Single			
	Columbicola columbae	4	
	Argas persicus	2	
Total		6	18.8
Double			
	Menopon gallinae + *Columbicola columbae*	1	3.1
Grand total		7	21.9

Table 4.44: Prevalence and predilection sites of ectoparasite on male *Turtur abyssinicus* in Zaria, Nigeria (n=20)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ± SE	Range	Site of recovery
Lice						
Columbicola columbae	4	20.0	56(94.9)	14.0±5.2	4-14	Quill feathers of wings and tail
Menopon gallinae	1	5.0	2(3.4)	2.0±0.0	1-2	Body, head and neck
Tick						
Argas persicus	1	5.0	1(1.7)	1.0±0.0	1-2	Wing web
Total	5	25.0	59(100.0)	11.8±4.3	1-14	Plumage

Table 4.45: Prevalence and predilection sites of ectoparasite on female *Turtur abyssinicus* in Zaria, Nigeria (n=12)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ± SE	Range	Site of recovery
Louse						
Columbicola columbae	1	8.3	4(66.7)	4.0±0.0	1-14	Quill feathers of wings and tail
Tick						
Argas persicus	1	8.3	2(33.3)	2.0±0.0	1-2	Wing web
Total	2	16.7	6(100.0)	3.0±1.0	1-14	Plumage

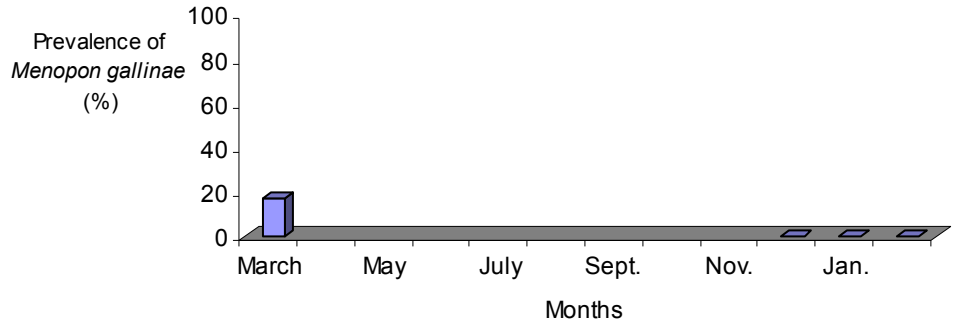
4.9.5 *Effect of ectoparasite infestations on body weight and PCV*

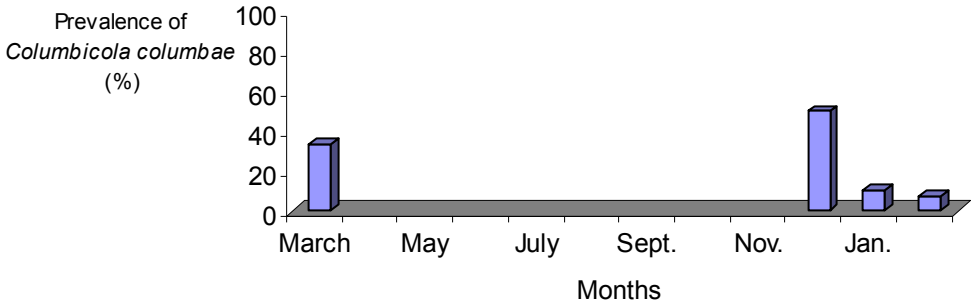
The body weights and PCV values of infested and non-infested doves were between 40-115 g and 35-65% respectively, and there was no significant difference between the mean weights and mean PCV values of infested (53.4±3.7 g, 46±2.0 %) and uninfested (65.1±3.9 g, 46±1.2 %) doves (P>0.05).

4.9.6 *Monthly prevalence and intensity of ectoparsites*

Turtur abyssinicus was sampled in March, December, January and February. Ectoparasites were recovered in all the months, with highest prevalence (50.0%) in March and December and lowest (10.0%) in January. The highest mean monthly intensity 22.0 ± 0.0 was in December and lowest 4.0+0.0 was in January.

The monthly prevalence of each ectoparasite of *Turtur abyssinicus* is presented in Figure 4.13, while the monthly prevalence, intensity and mean monthly intensity of individual ectoparasites on *Turtur abyssinicus* are presented in Appendix 17.





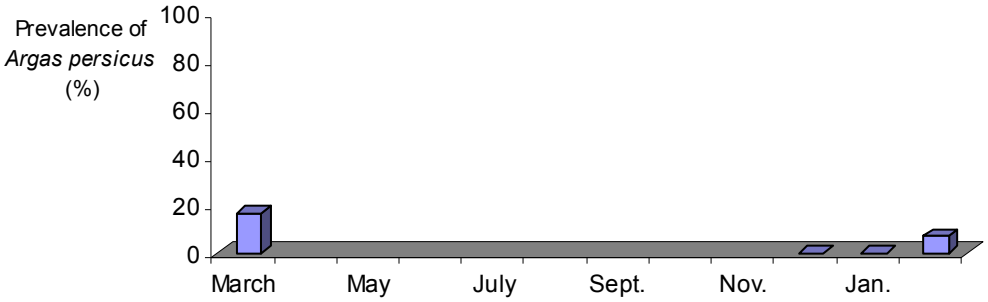


Figure 4.13: Monthly prevalence of individual ectoparasites on *Turtur abyssinicus* in Zaria, Nigeria

Menopon gallinae was recovered in March with a prevalence of 16.7% and mean intensity of 2.0 ± 0.0. *Columbicola columbae* was recovered in all the months, with highest prevalence (50.0%) in December and lowest (7.1%) in February. The highest mean monthly intensity 24.0 ± 0.0 was in February and lowest 4.0 ± 0.0 was in January. *Argas persicus* was recovered in March and February with highest prevalence (16.7%) in March and lowest (7.1%) in February. The highest mean monthly intensity 2.0 ± 0.0 was in March and lowest 1.0 ± 0.0 was in February.

4.10 **Helminths of *Turtur abyssinicus***

4.10.1 *Prevalence of helminths*

Of the 32 *Turtur abyssinicus* examined, 14 (43.8%) were infected by helminths. Five species of helminths were identified and all were cestodes.

These comprised of *R. tetragona* 1 (3.1%), *R. cesticillus* 4 (12.5%). *R. magninumida* 3 (9.4%), *R. echinobothrida* 5 (15.6%) and *Amoebotaenia cuneata* 1 (3.1%) (Plates XII, XIII, XIV, XV, XXII, Table 4.46 and Appendix 5).

A total of 34 parasites were recovered and the relative abundance of the helminths were *R. tetragona* 4 (11.8%), *R. cesticillus* 8 (23.5%), *R. magninumida* 8 (23.5%), *R. echinobothrida* 12 (35.3%) and *Amoebotaenia cuneata* 2 (5.9%). The mean intensities of the helminths were *R. tetragona* 4.0±0.0, *R. cesticillus* 2.0±0.4, *R. magninumida* 2.7± 0.7, *R. echinobothrida* 2.4±0.4 and *A. cuneata* 2.0±0.0. All the helminths were restricted to the ileum (Table 4.46 and Appendix 7). There were statistically significant differences between the prevalence and mean intensity of the parasites ($P<0.05$).

4.10.2 *Intensity of helminth infections*

Table 4.47 shows the intensity of helminth infections in *Turtur abyssinicus*. All the individuals with helminths were in the lower class interval of 1-5 (with low parasite burden).

4.10.3 *Frequency distribution of single and mixed infections*

Single infection 14 (43.8%) was the only type observed (Table 4.48), this involved *R. tetragona*, *R. cesticillus*, *R. magninumida*, *R. echinobothrida* and *Amoebotaenia cuneata*.

4.10.4 *Sex-related helminth infections of Turtur abyssinicus*

A total of 20 males and 12 females were examined and only 11(55.0%) of the male birds and 3 (25.0%) of the females had helminth infections (Table 4.49, 4.50, Appendix 6 and 8). A total of 26 (76.5%) helminths was recovered from the males and 8 (23.5%) from the females. Mean intensity in the males was 2.4 ± 0.3 and 2.7 ± 0.6 in the females. Chi-square test showed no significant association between sex and infection ($P>0.05$).

Table 4.46: Prevalence and predilection sites of intestinal helminths in *Turtur abyssinicus* in Zaria, Nigeria (n=32)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	1	3.1	4 (11.8)	4.0±0.0	1-4	Ileum
Raillietina cesticillus	4	12.5	8 (23.5)	2.0±0.4	1-3	Ileum
Raillietina magninumida	3	9.4	8 (23.5)	2.7±0.7	2-4	Ileum
Raillietina echinobothrida	5	15.6	12 (35.3)	2.4±0.4	2-4	Ileum
Amoebotaenia cuneata	1	3.1	2 (5.9)	2.0±0.0	1-2	Ileum
Total	14	43.8	34 (100.0)	2.4±1.0	1-4	Ileum

Table 4.47: Intensity of helminth infections in *Turtur abyssinicus* in Zaria, Nigeria

Helminths and frequency of intensity						
Class interval	*Raillietina tetragona*	*Raillietina Cesticillus*	*Raillietina Magninumida*	*Raillietina echinobothrida*	*Amoebotaenia cuneata*	Total (%)
1-5	1	4	3	5	1	14(43.8)
6-10	0	0	0	0	0	0(00)
11-15	0	0	0	0	0	0(00)
16-20	0	0	0	0	0	0(00)
21-25	0	0	0	0	0	0(00)
Total	1(3.1%)	4(12.5%)	3(9.4%)	5(15.6%)	1(3.1%)	

Table 4.48: Frequency distribution of single and mixed helminth infections in *Turtur abyssinicus* in Zaria, Nigeria

	Parasite	Frequency of occurrence Total	Percentage (%)
None		18	56.3
Single			
	Raillietina tertragona	1	
	Raillietina cestillus	4	
	Raillietina magninumida	3	
	Raillietina echinobothrida	5	
	Amoebotaenia cuneata	1	
Total		14	43.8

Table 4.49: Prevalence and predilection sites of intestinal helminths in male *Turtur abyssinicus* in Zaria, Nigeria (n=20)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina tetragona	1	5.0	4 (15.4)	4.0±0.0	1-4	Ileum
Raillietina cesticillus	3	15.0	6 (23.1)	2.0±0.4	1-3	Ileum
Raillietina magninumida	2	10.0	6 (23.1)	3.0±1.0	2-4	Ileum
Raillietina echinobothrida	4	20.0	8 (30.8)	2.0±0.0	2-4	Ileum
Amoebotaenia cuneata	1	5.0	2 (7.7)	2.0±0.0	1-2	Ileum
Total	11	55.0	26(100.0)	2.4±0.3	1-4	Ileum

Table 4.50: Prevalence and predilection sites of intestinal helminths in female *Turtur abyssinicus* in Zaria, Nigeria (n=12)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina cesticillus	1	8.3	2 (25.0)	2.0±0.0	1-2	Ileum
Raillietina magninumida	1	8.3	2 (25.0)	2.0±0.0	1-2	Ileum
Raillietina echinobothrida	1	8.3	4 (50.0)	4.0±0.0	1-4	Ileum
Total	3	25.0	8 (100.0)	2.7±0.6	1-4	Ileum

4.10.5 *Effect of helminth infections on body weight and PCV*

The body weights and PCV values of infected and non-infected doves were within 40-115 g and 35-65% respectively and there was no significant difference between the mean body weights and mean PCV values of infected (64.1±7.0 g, 48±1.6 %) and uninfected (64.2±4.3 g, 45±1.4 %) doves (P>0.05).

4.10.6 *Monthly prevalence and intensity of helminths*

Turtur abyssinicus was sampled in January, February, March and December, with highest prevalence (50.0%) in March and December and lowest (40.0%) in January.

The highest mean monthly intensity was 4.0 ± 0.0 in December and the lowest was 1.6 ± 0.2 in February. There were no significant differences between the monthly prevalence and mean monthly intensity (P>0.05).

The monthly prevalence of each helminth of *Turtur abyssinicus* is presented in Figure 4.14, while the monthly prevalence, intensity and mean monthly intensity of individual helminths on *Turtur abyssinicus* are presented in Appendix 18.

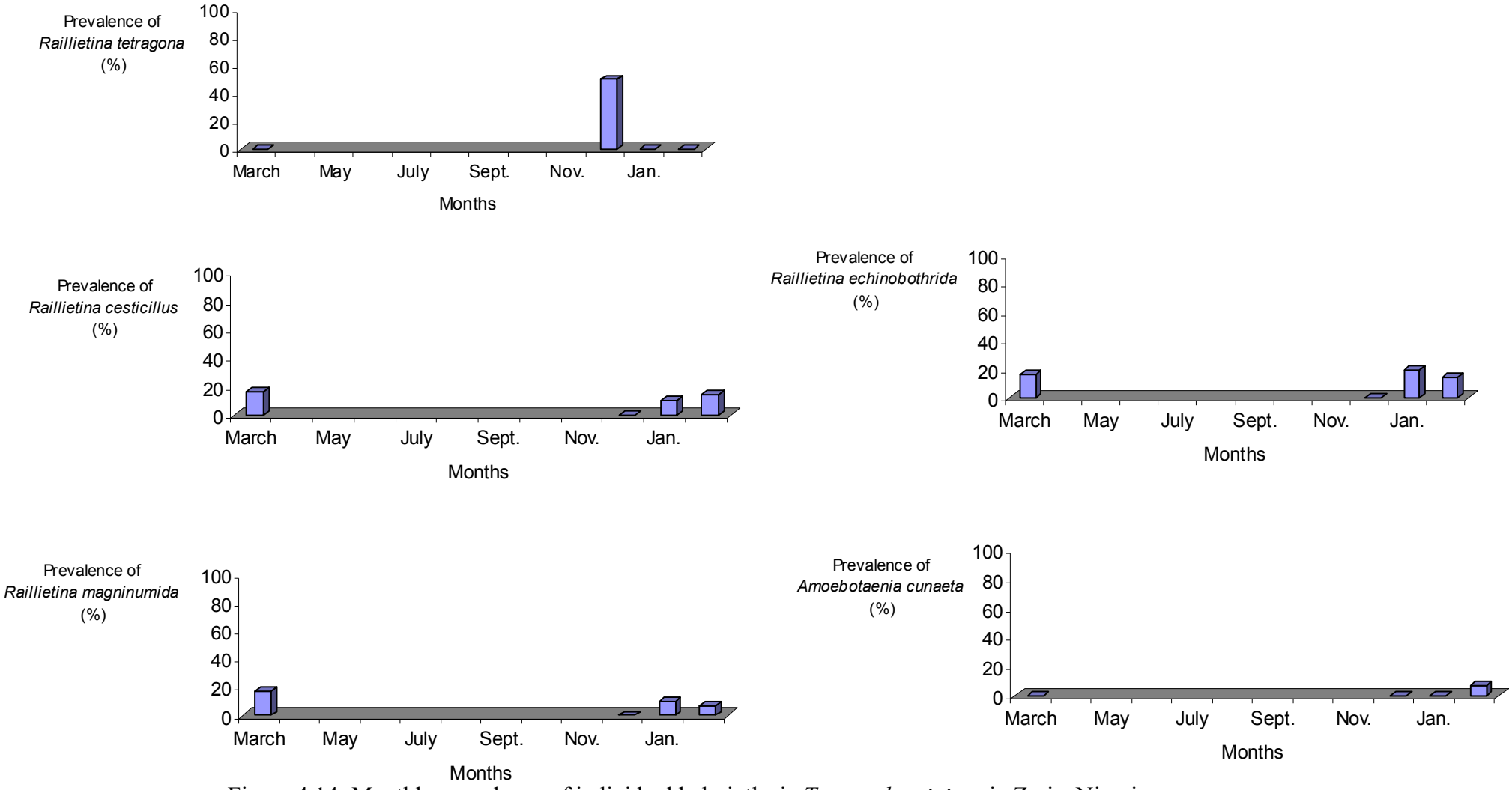


Figure 4.14: Monthly prevalence of individual helminths in *Turtur abyssinicus* in Zaria, Nigeria

Raillietina tetragona was recovered only in December with a prevalence of 50.0% and mean intensity of 4.0±0.0. *Raillietina cesticillus* was recovered in three months with highest prevalence (16.7%) in March and lowest (10.0%) in January. The highest mean monthly intensity was 3.0±0.0 in January and the lowest was 1.5±0.5 in February. *Raillietina magninumida* was recovered in three months with highest prevalence (16.7%) in March and lowest (7.1%) in February. The highest mean monthly intensity was 4.0±0.0 in January and the lowest was 2.0±0.0 in March and February. *Raillietina echinobothrida* was recovered in three months with highest prevalence (20.0%) in January and lowest (14.3%) in February. The highest mean monthly intensity was 3.0±1.0 in January and the lowest was 2.0±0.0 in March and February. *Amoebotaenia cuneata* was recovered only in February with a prevalence of 7.1% and mean intensity of 2.0±0.0.

4.11 **Ectoparasites of *Streptopelia vinacea***

4.11.1 *Prevalence of ectoparasites*

Of the 6 *Streptopelia vinacea* examined, 2 (33.3%) were infested by ectoparasites. Two species of lice *Menopon gallinae* 2 (33.3%) and *Columbicola columbae* 1 (16.7%) and one species of fly *P. canariensis* 1 (16.7%) were identified (Plates VII, VIII, X, Table 4.51 and Appendix 1).

A total of 25 parasites were recovered and the relative abundance of the parasites was *Menopon gallinae* 8 (32.0%), *Columbicola columbae* 15 (60.0%) and *P. canariensis* 2 (8.0%). The mean intensities of the parasites were *Menopon gallinae* 4.0 ± 0.0,

Columbicola columbae 15.0 ± 0.0 and *P. canariensis* 2.0 ± 0.0 (Table 4.51 and Appendix 3).

There were no significant differences between the prevalence and mean intensity of the three ectoparasites (P>0.05).

4.11.2 *Intensity of ectoparasite infestations*

Table 4.52 shows intensity of ectoparasite infestations on *S. vinacea*. The number of individuals in the lower class interval, 1-5 (with low parasite burden) were more than those in the higher class interval, 11-15 (with high parasite burden).

4.11.3 *Frequency distribution of single and mixed infestations*

Only double infestations 02 (33.3%) were observed (Table 4.53).

4.11.4 *Sex-related ectoparasite infestations of Streptopelia vinacea*

A total of 2 males and 4 females were examined and only 1 (50.0%) male and 1 (25.0%) female bird had ectoparasites. A total of 19 (76.0%) ectoparasites were recovered from the male and 6 (24.0%) recovered from the female. The mean intensity in the male was 19.0±5.6 and 6.0±1.0 in the female, giving a ratio of male:female infestation intensity as 3:1 (Table 4.54, 4.55, Appendix 2 and 4). Chi square analysis showed no significant association between sex and infestation (P>0.05).

Table 4.51: Prevalence and predilection sites of ectoparasites on *Streptopelia vinacea* in Zaria, Nigeria (n=6)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Columbicola columbae	1	16.7	15(60.0)	15.0±0.0	1-15	Quill feathers of wings and tail
Menopon gallinae	2	33.3	8(32.0)	4.0±0.0	1-4	Body, head and neck
Fly						
Pseudolynchia canariensis	1	16.7	2(8.0)	2.0±0.0	1-2	Down and contour feathers of body
Total	2	33.3	25(100.0)	12.5±3.0	1-15	Plumage

Table 4.52: Intensity of ectoparasite infestations on *S. vinacea* in Zaria, Nigeria

	Ectoparasites and frequency of intensity			
Class interval	*Columbicola columbae*	*Menopon gallinae*	*Pseudolynchia Canariensis*	Total (%)
1-5	0	2	1	3(50)
6-10	0	0	0	0(00)
11-15	1	0	0	1(16.7)
Total	1(16.7%)	2 (33.3%)	1(16.7%)	

Table 4.53: Frequency distribution of single and mixed ectoparasite infestations on *Streptopelia vinacea* in Zaria, Nigeria

Infestation type	Parasite	Frequency of occurrence Total	Percentage (%)
Double			
	Menopon gallinae + *Columbicola columbae*	1	
	Menopon gallinae + *Pseudolynchia canariensis*	1	
Total		2	33.3

Table 4.54: Prevalence and predilection sites of ectoparasites on male *Streptopelia vinacea* in Zaria, Nigeria (n=2)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Columbicola columbae	1	50.0	15(78.9)	15.0±0.0	1-15	Quill feathers of wings and tail
Menopon gallinae	1	50.0	4(21.1)	4.0±0.0	1-4	Body, head and neck
Total	1	50.0	19(100.0)	19.0±5.6	1-15	Plumage

Table 4.55: Prevalence and predilection sites of ectoparasites on female *Streptopelia vinacea* in Zaria, Nigeria (n=4)

Parasite	Number of Columbids infested	Prevalence (%)	Total number of ectoparasites recovered (%)	Mean intensity ±SE	Range	Site of recovery
Lice						
Menopon gallinae	1	25.0	4(66.7)	4.0±0.0	1-4	Body, head and neck
Fly						
Pseudolynchia canariensis	1	25.0	2(33.3)	2.0±0.0	1-2	Down and contour feathers of body
Total	1	25.0	6 (100.0)	6.0±1.0	1-4	Plumage

4.11.5 *Effect of ectoparasite infestations on body weight and PCV*

The body weights and PCV values of infested and non-infested doves were between 40-105 g and 35-65% respectively and there was no significant difference between the mean body weights and mean PCV values of infested (91.3 ± 1.3 g, 49 ± 0.7 %) and uninfested (80.3 ± 3.2 g, 54 ± 2.5 %) doves ($P>0.05$).

4.11.6 *Monthly prevalence and intensity of ectoparasites*

Streptopelia vinacea was sampled only in April, May and December. Ectoparasites were only recovered in April and May with 100.0% prevalence. The highest 19.0 ± 5.6 mean monthly intensity of ectoparasites was in April and lowest 6.0 ± 1.0 was in May. The monthly prevalence of each ectoparasite of *Streptopelia vinacea* is presented in Figure 4.15, while the monthly prevalence, intensity and mean monthly intensity of individual ectoparasites on *Streptopelia vinacea* is presented in Appendix 19.

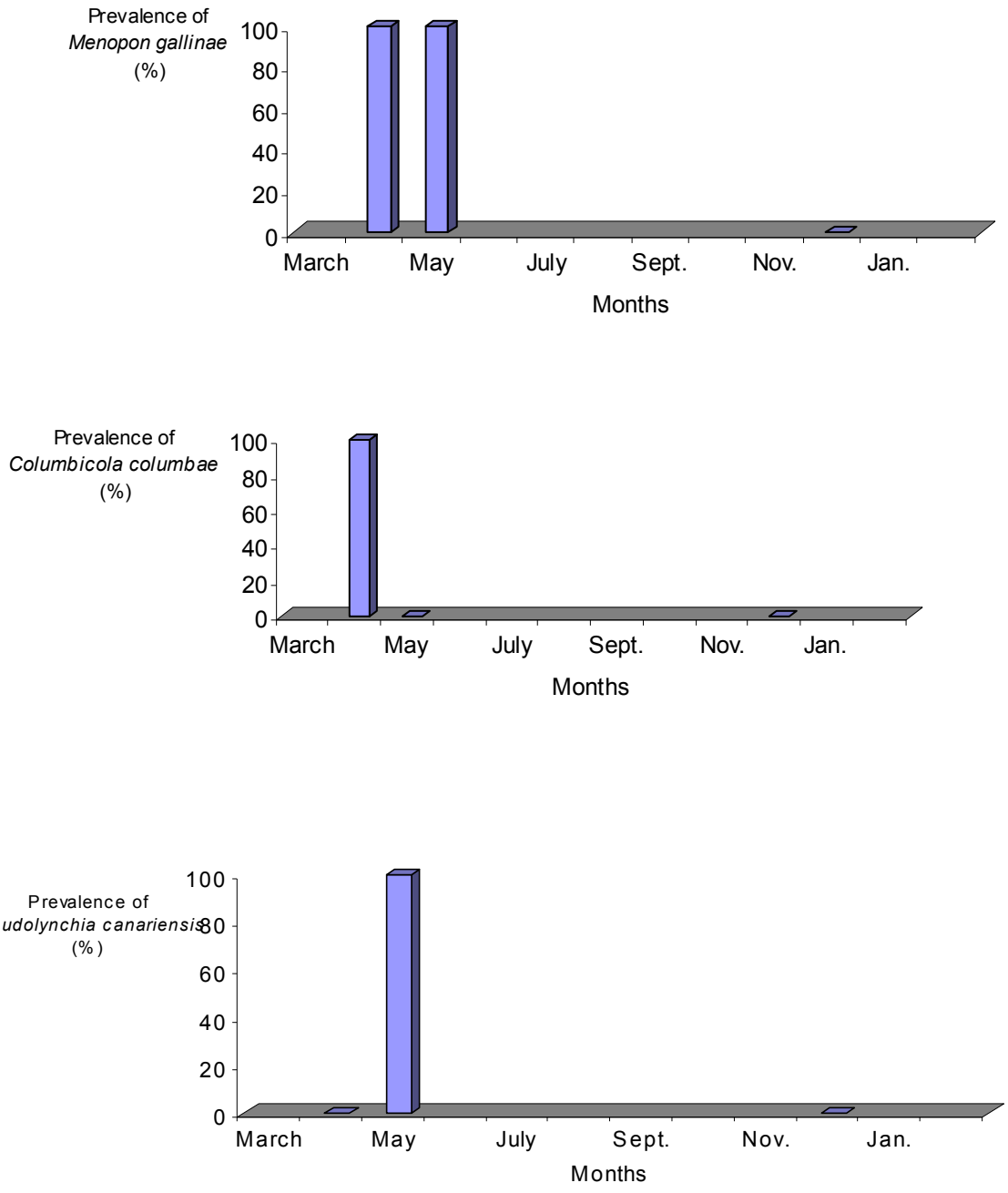


Figure 4.15: Monthly prevalence of individual ectoparasites on *S. vinacea* in Zaria, Nigeria

Menopon gallinae was recovered in April and May with 100.0% prevalence and mean monthly intensity of 4.0 ± 0.0 for both months.

Columbicola columbae was recovered only in April with 100.0% prevalence and mean intensity of 15.0 ± 0.0.

Pseudolynchia canariensis was recovered only in May with 100.0% prevalence and mean intensity of 2.0 ± 0.0.

4.12 **Helminths of *Streptopelia vinacea***

4.12.1 *Prevalence of helminths*

Of the six *S. vinacea* examined, three (50%) were infected by helminths. Three cestodes were identified and these included 2 (33.3%) in *R. cesticillus*, 1 (16.7%) in *H. carioca* and 1 (16.7%) in *H. cantaniana* (Plates XIV, XVI, XVII, Table 4.56 and Appendix 5).

A total of 16 parasites were recovered and the relative abundance of the helminths were *R. cesticillus* 5 (31.3%), *H. carioca* 7 (43.8%) and *H. cantaniana* 4 (25.0%). The mean intensities for the helminths were follows: *R. cesticillus* 2.5 ± 0.7, *H. carioca* 7.0 ± 0.0 and *H. cantaniana* 4.0 ± 0.0. There were no statistically significant differences between the prevalence and mean intensity of the parasites (P>0.05). The helminths were all restricted to the ileum (Table 4.56 and Appendix 7).

4.12.2 *Intensity of helminth infections*

Table 4.57 shows the intensity of helminths infections in *S. vinacea.* All the individuals with helminths were in the lower class intervals of 1-5 and 6-10 (with low parasite burden).

4.12.3 *Frequency distribution of single and mixed infections*

Single infection was observed in 2 (33.3%) birds and double infection in 1 (16.7%) bird (Table 4.58).

Table 4.56: Prevalence and predilection sites of helminths in *Streptopelia vinacea* in Zaria, Nigeria (n=6)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina cesticillus	2	33.3	5 (31.3)	2.5±0.7	2-3	Ileum
Hymenolepis carioca	1	16.7	7 (43.8)	7.0±0.0	1-7	Ileum
Hymenolepis cantaniana	1	16.7	4 (25.0)	4.0±0.0	1-4	Ileum
Total	3	50.0	16 (100.0)	5.3±1.1	1-7	Ileum

Table 4.57: Intensity of helminth infections in *S. vinacea* in Zaria, Nigeria

Helminths and frequency of intensity				
Class interval	*Raillietina cesticillus*	*Hymenolepis carioca*	*Hymenolepi Cantaniana*	Total (%)
1-5	2	0	1	3(50)
6-10	0	1	0	1(16.7)
11-15	0	0	0	0(00)
16-20	0	0	0	0(00)
21-25	0	0	0	0(00)
Total	2(33.3%)	1(16.7%)	1(16.7%)	

Table 4.58: Frequency distribution of single and mixed helminth infections in *S. vinacea* in Zaria, Nigeria

Infection type	Parasite	Frequency of occurrence	
		Total	Percentage (%)
None		3	50.0
Single	*Raillietina cesticillus*	2	33.3
Double	Hymenolepis carioca + Hymenolepis cantaniana	1	16.7
Total		3	50.0

4.12.4 *Sex-related helminth infections of Turutr abyssinicus*

A total of 2 males and 4 females were examined and helminth infections in the male birds was 1 (50.0%) and 2 (50.0%) in the females. A total of 3 (18.8%) helminths were recovered from the male and 13 (81.3%) from the females. Mean intensity in the male was 3.0 ± 0.0 and 6.5 ± 2.1 in the females (Table 4.59, 4.60, Appendix 6 and 8). Chi-square test showed no significant association between sex and infection (P>0.05).

4.12.5 *Effect of helminth infections on body weight and PCV*

The body weights and PCV values of infected and non-infected doves were between 40-105 g and 35-65% respectively and there was no significant difference between the mean body weights and mean PCV values of infected (89.0 ± 1.7 g, 54 ± 3.6 %) and uninfected (78.2 ± 3.5 g, 53 ± 2.8 %) doves (P>0.05).

4.12.6 *Monthly prevalence and intensity of helminths*

Streptopelia vinacea was sampled only in April, May and December. The higher 100.0% prevalence was recorded in the birds in April and May and the lower 25.0% in December. The highest mean monthly intensity was 11.0 ± 0.0 in December and the lowest was

2.0 ± 0.0 in May. There were no significant differences between the monthly prevalence and mean monthly intensity (P>0.05).

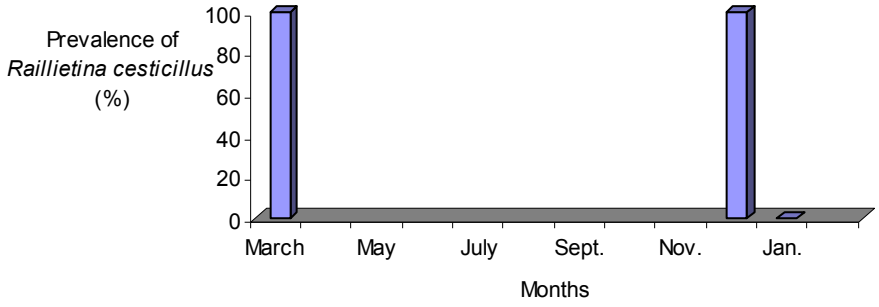
The monthly prevalence of each helminth in *S. vinacea* is presented in Figure 4.16, while the monthly prevalence, intensity and mean monthly intensity of individual helminths in *S. vinacea* are presented in Appendix 20.

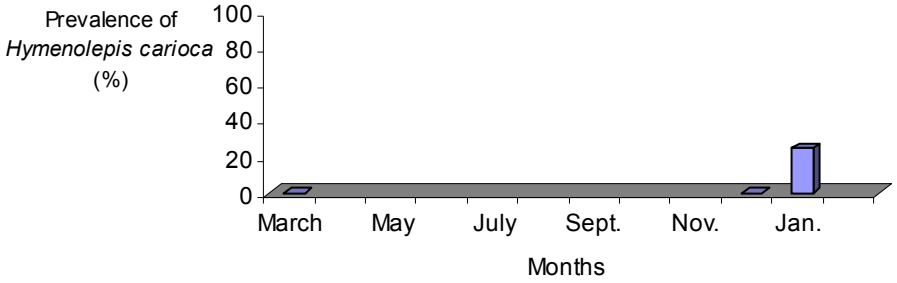
Table 4.59: Prevalence and predilection sites of helminths in male *Streptopelia vinacea* in Zaria, Nigeria (n=2)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina cesticillus	1	50.0	3 (100.0)	3.0±0.0	1-3	Ileum
Total	1	50.0	3 (100.0)	3.0±0.0	1-3	Ileum

Table 4.60: Prevalence and predilection sites of helminths in female *Streptopelia vinacea* in Zaria, Nigeria (n=4)

Parasite	Number of birds infected	Prevalence (%)	Total number of helminths recovered (%)	Mean intensity ± SE	Range	Site of recovery
Raillietina cesticillus	1	25.0	2 (15.4)	2.0±0.0	1-2	Ileum
Hymenolepis carioca	1	25.0	7 (53.8)	7.0±0.0	1-7	Ileum
Hymenolepis cantaniana	1	25.0	4 (30.8)	4.0±0.0	1-4	Ileum
Total	2	50.0	13 (100.0)	6.5±2.1	2-7	Ileum





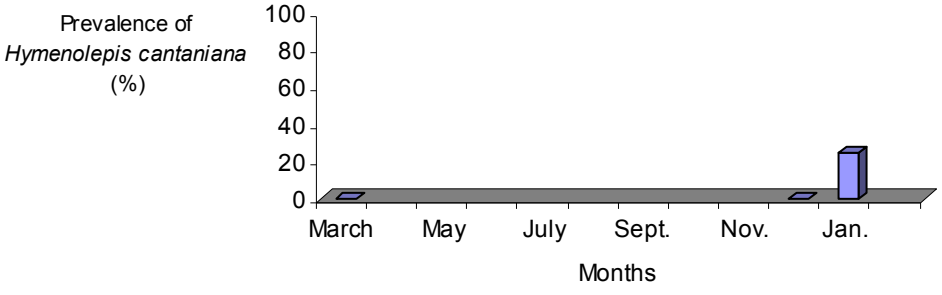


Figure 4.16: Monthly prevalence of individual helminths in *S. vinacea* in Zaria, Nigeria

Raillietina cesticillus was recovered in April and May with 100.0% prevalence in both months. The mean monthly intensity was 3.0 ± 0.0 in April and 2.0 ± 0.0 in May. *Hymenolepis carioca* and *Hymenolepis cantaniana* were recorded only in December with prevalence of 25.0% each and mean intensity of 7.0 ± 0.0 and 4.0 ± 0.0 respectively.

4. 13 **Experimental infection of *Columba livia domestica* with *Ascaridia galli***

4.13.1 *Changes in body weight*

The weekly mean body weights of infected and non-infected pigeons are represented in Figure 4.17. Weight losses were more consistent in the infected group than in the control group and weekly changes in body weights in the infected group (Group A) were significant ($P<0.05$) compared with those in the non-infected group (Group B) which were not significant ($P>0.05$).

4.13.2 *Changes in packed cell volume (PCV)*

The mean Packed Cell Volume values of birds in the infected and non-infected group are shown in Figure 4.18. There was no consistent change in the weekly mean PCV values of the infected and non-infected groups. Weekly changes in PCV values were rather erratic in both groups. However, the differences were not significant ($P>0.05$). The PCV values of control birds were lower than that of infected birds for up to nine weeks post infection (Figure 4.18).

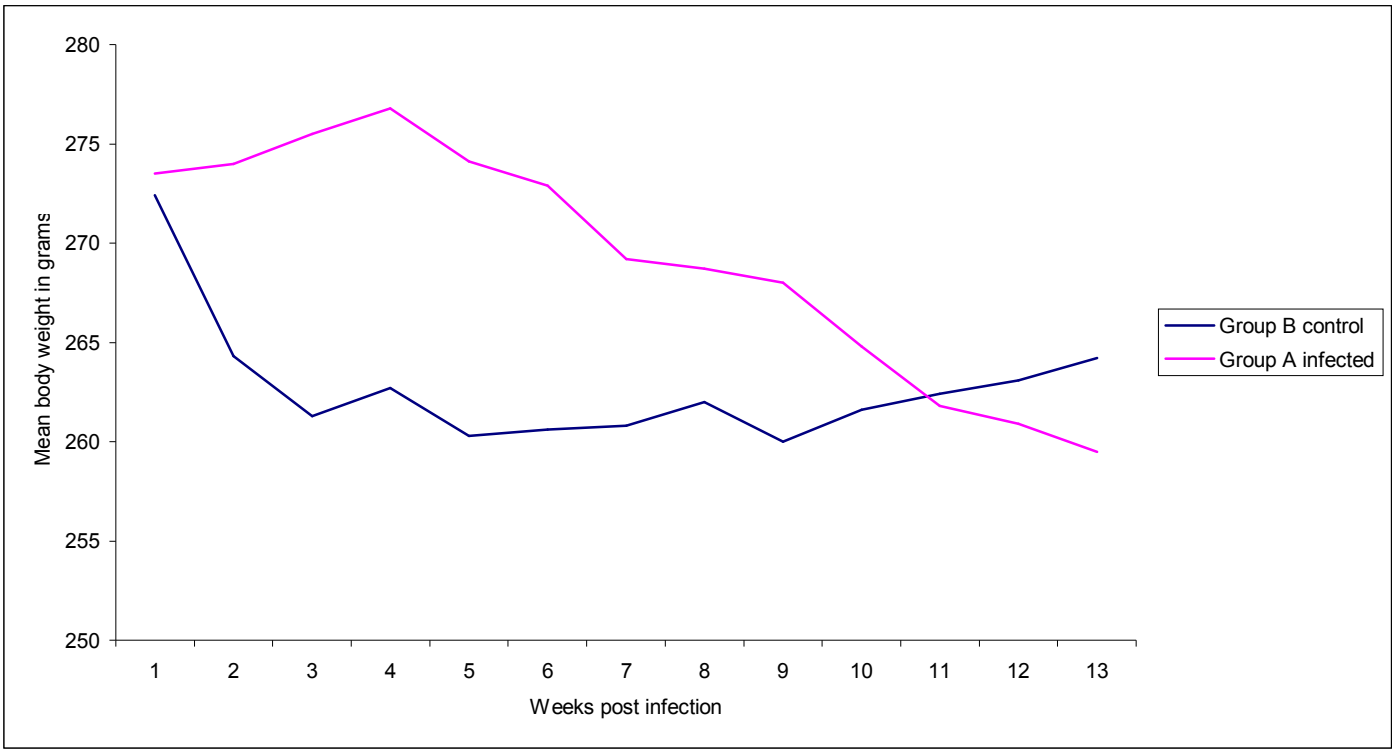


Figure 4.17: Weekly mean body weights of infected and non-infected domestic pigeons

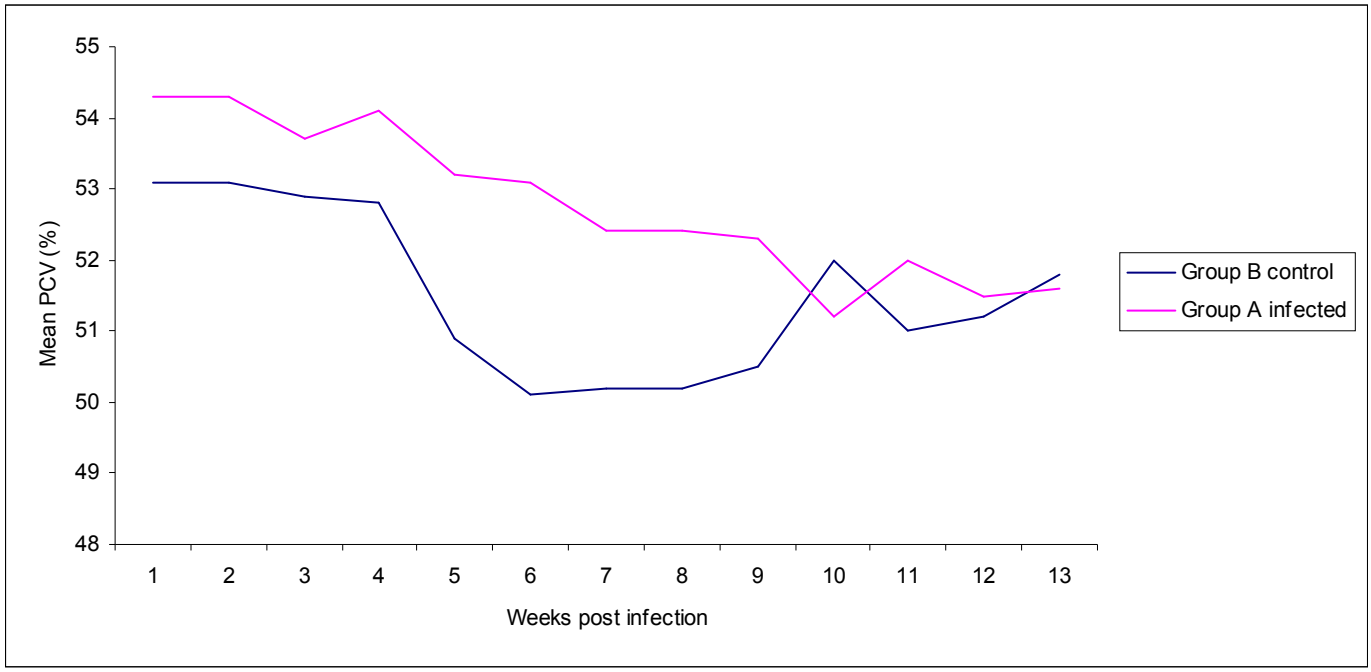


Figure 4.18: Weekly mean PCV values of infected and non-infected domestic pigeons

4.13.3 *Changes in haemoglobin level*

The weekly mean Hb level values of birds in the infected and non-infected groups are shown in Figure 4.19. There was no consistent change in the weekly mean Hb values of the infected and non-infected groups. The differences between the Hb levels of the two groups for the whole period of experimentation were not significant ($P>0.05$). However, the mean Hb values of infected birds were higher than the values of non-infected birds (Figure 4.19).

4.13.4 *Changes in total plasma protein*

Figure 4.20 shows the weekly mean total plasma protein values for the infected and non-infected groups. The infected birds had lower mean total plasma proteins values than those of the non-infected birds (control). Total plasma protein values decreased slightly in the infected group and almost consistent in the control group. Differences in the total plasma protein values in both infected and non-infected groups, were not significant ($P> 0.05$).

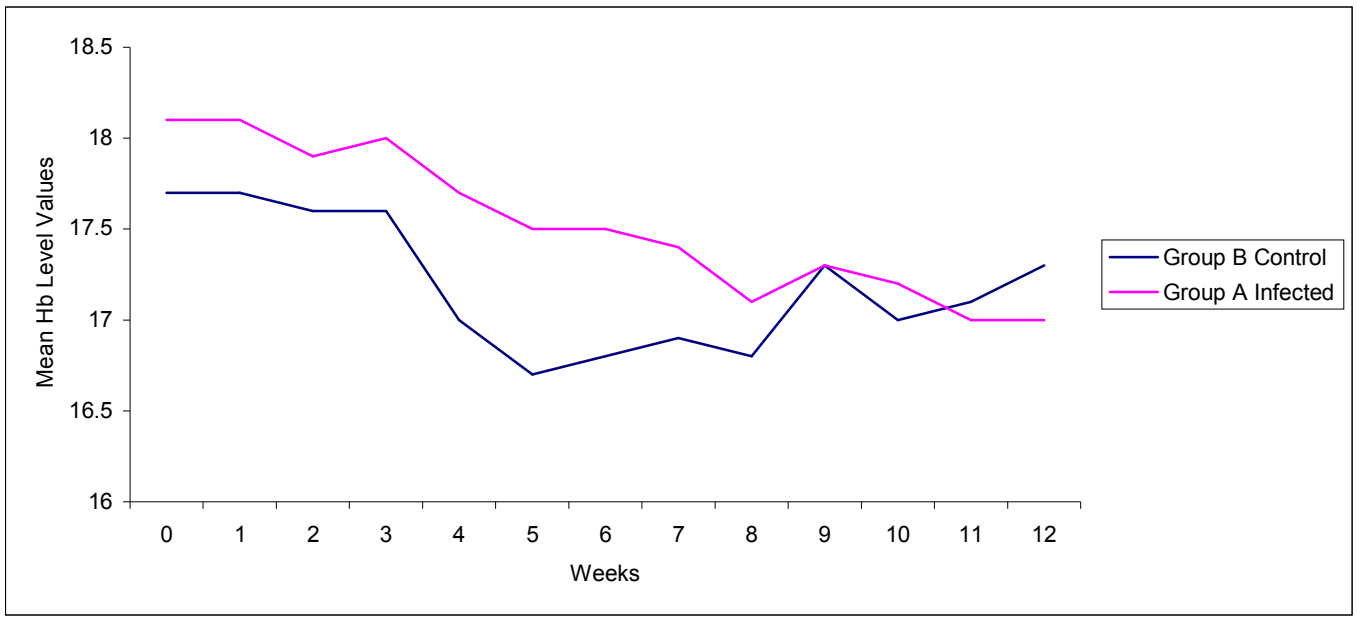


Figure 4.19: Weekly mean Hb levels of infected and non-infected domestic pigeons

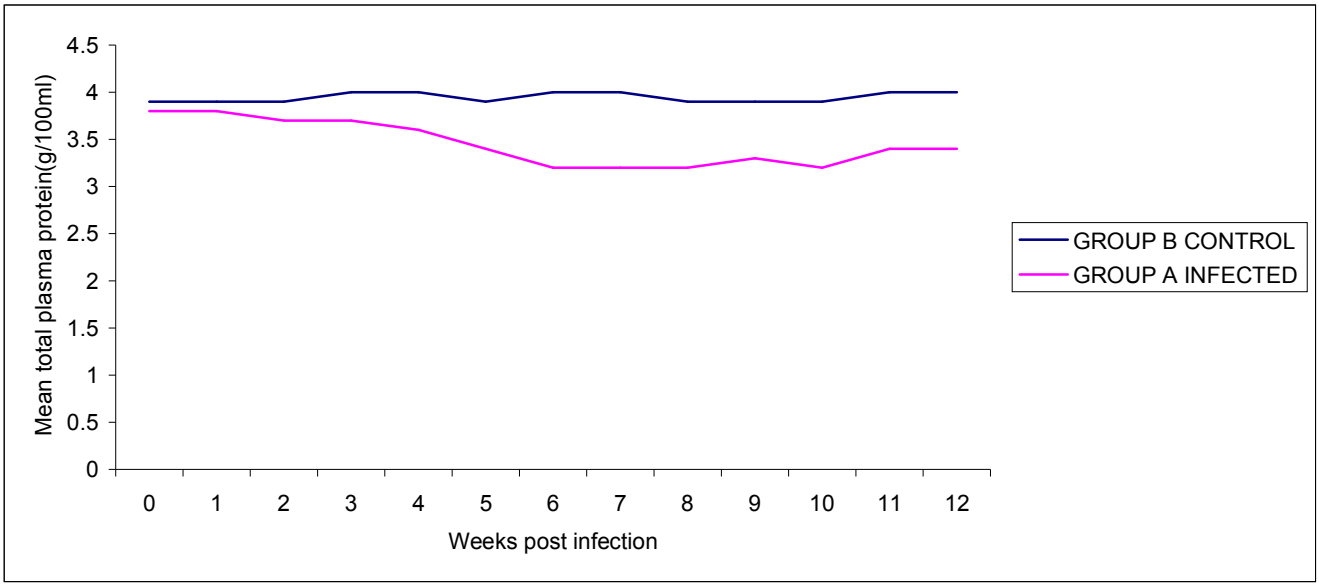


Figure 4.20: Weekly mean total plasma protein values of infected and non-infected domestic pigeons

4.13.5 *Clinical signs*

Blood-tinged diarrhoea, inappetance, increased thirst, dropsy looks, down ward nodding of head, ruffled feathers, shivering, emaciation and dirty cloacal region were some of the clinical signs observed among the infected group.

4.13.6 *Worm recovery*

At the termination of the experiment, 87 parasites were recovered from then small intestine of 14 (46.7%) birds in the infected group. The highest number of worms recovered from one bird was 12 and the lowest was 2. No worm was recovered from any bird in the non-infected group.

4.13.7 *Histopathology*

Histopathology showed that the liver of infected birds, from which worms were recovered, had fatty degeneration and areas of coagulation, necrosis of the hepatic cells were most predominant at the portal areas. There were mononuclear and polymorphonuclear cellular infiltrations in the necrotized areas. The liver had congested blood vessels and congested sinusoids (Plate XXIII).

The lungs of the infected pigeons had haemorrhagic areas, congested blood vessels and haemosiderosis. There was mononuclear and polymorphonuclear cellular infiltration at the peribronchiolar and interalveolar septae which extended and filled some alveoli (Plate XXIV).

The heart had focal areas of necrosis of the myocardial cells and few mononuclear and polymorphonuclear cells in the necrotized areas (Plate XXV).

The kidneys had renal tubular necrosis infiltrated by few mononuclear and polymorphonuclear cells (Plate XXVI).

The infected pigeons had necrosis of the intestine that involved the villi, intestinal glands and the muscularis mucosae of the intestine. There were mononuclear amd polymorphonuclear cells in the necrotized areas (Plate XXVII).

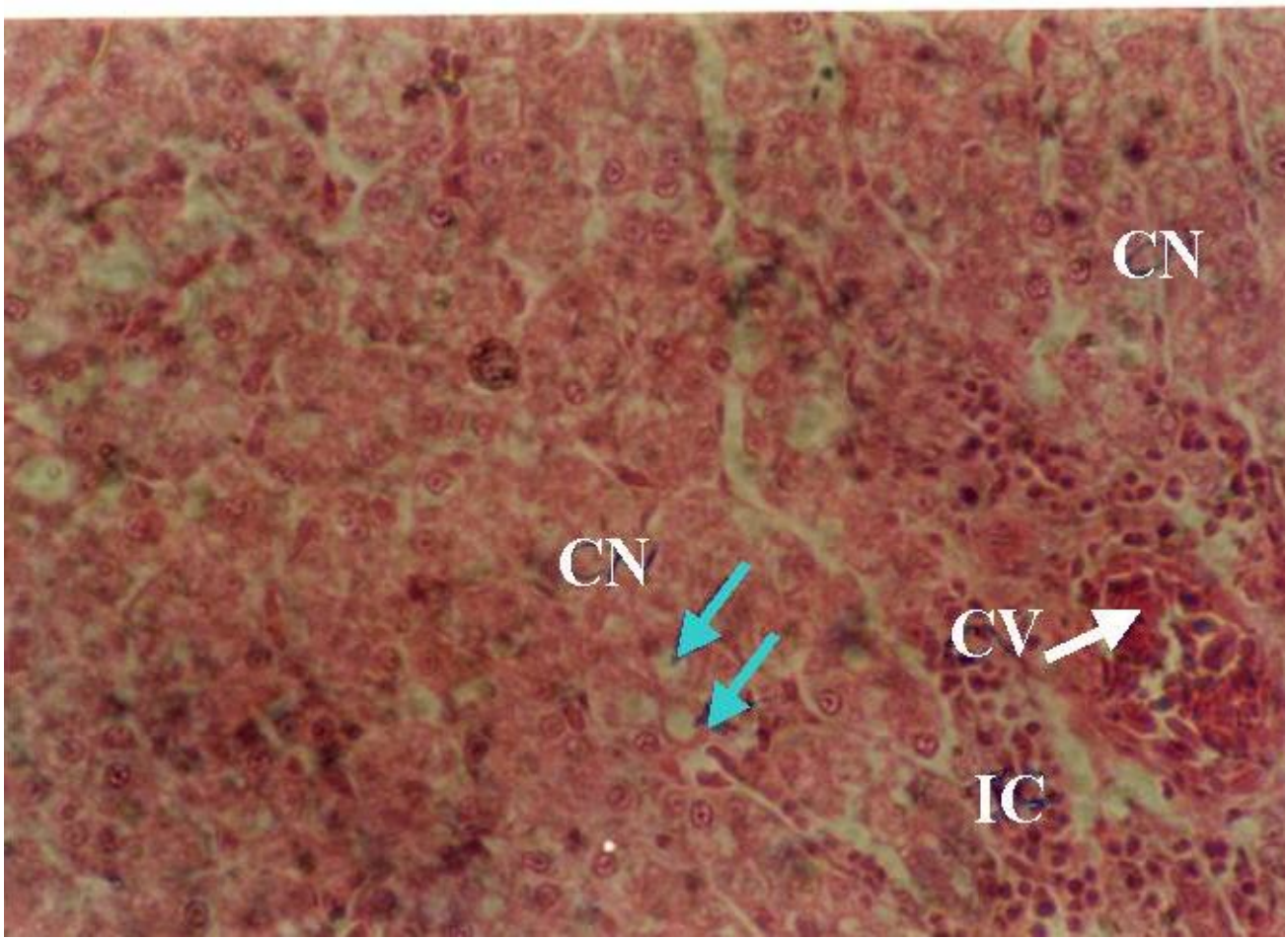


Plate XXIII: Photomicrograph of a section of liver from an infected pigeon, showing coagultion necrosis (CN) of the hepatic cells, fatty degeneration (arrow heads), inflammatory cells (IC) and congested central vein (CV). H&E Stain. X400

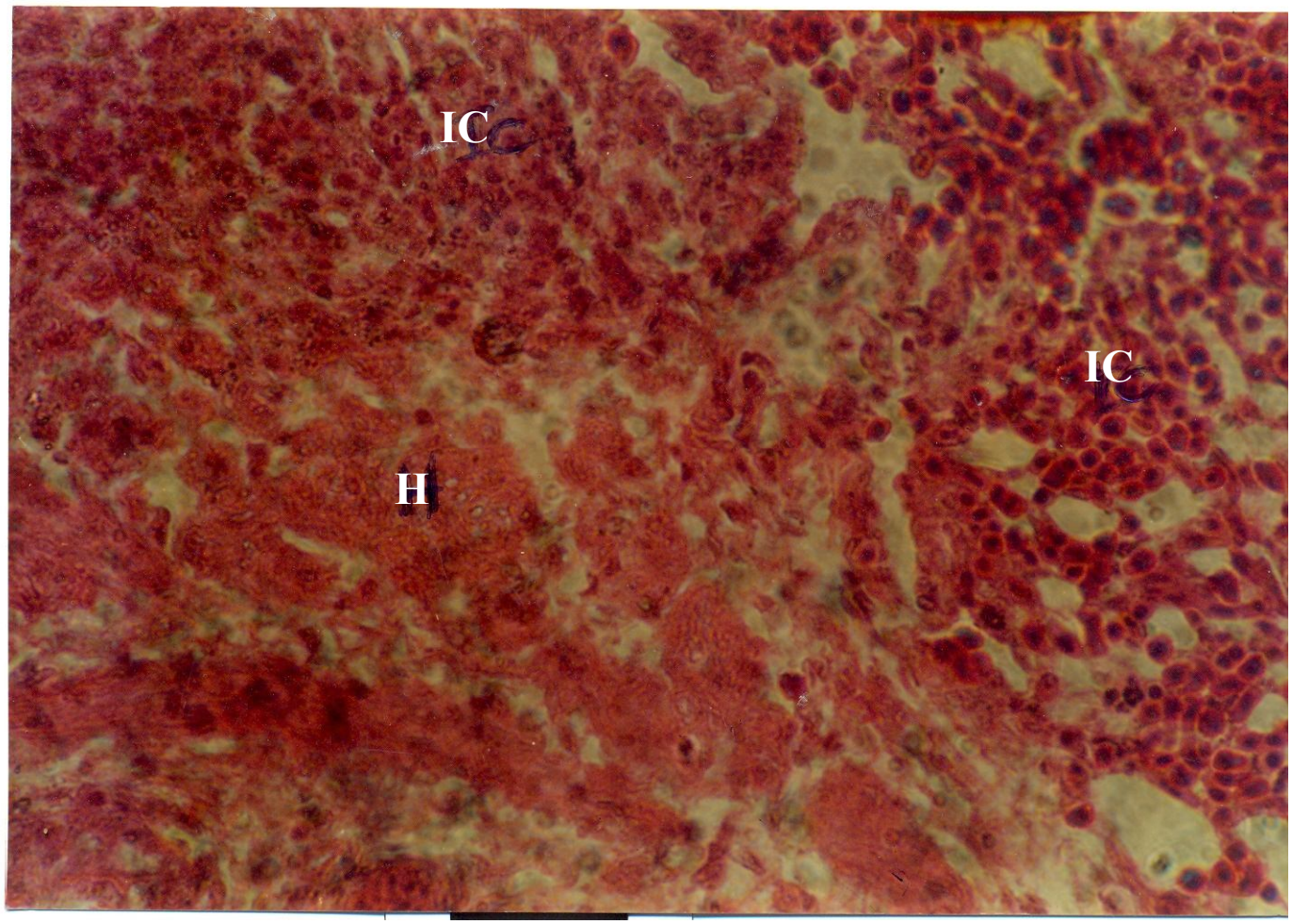


Plate XXIV: Photomicrograph of a section of lung from an infected pigeon, showing haemorrhage (H) and the inflammatory cells (IC) in the lung. H&E Stain. X400

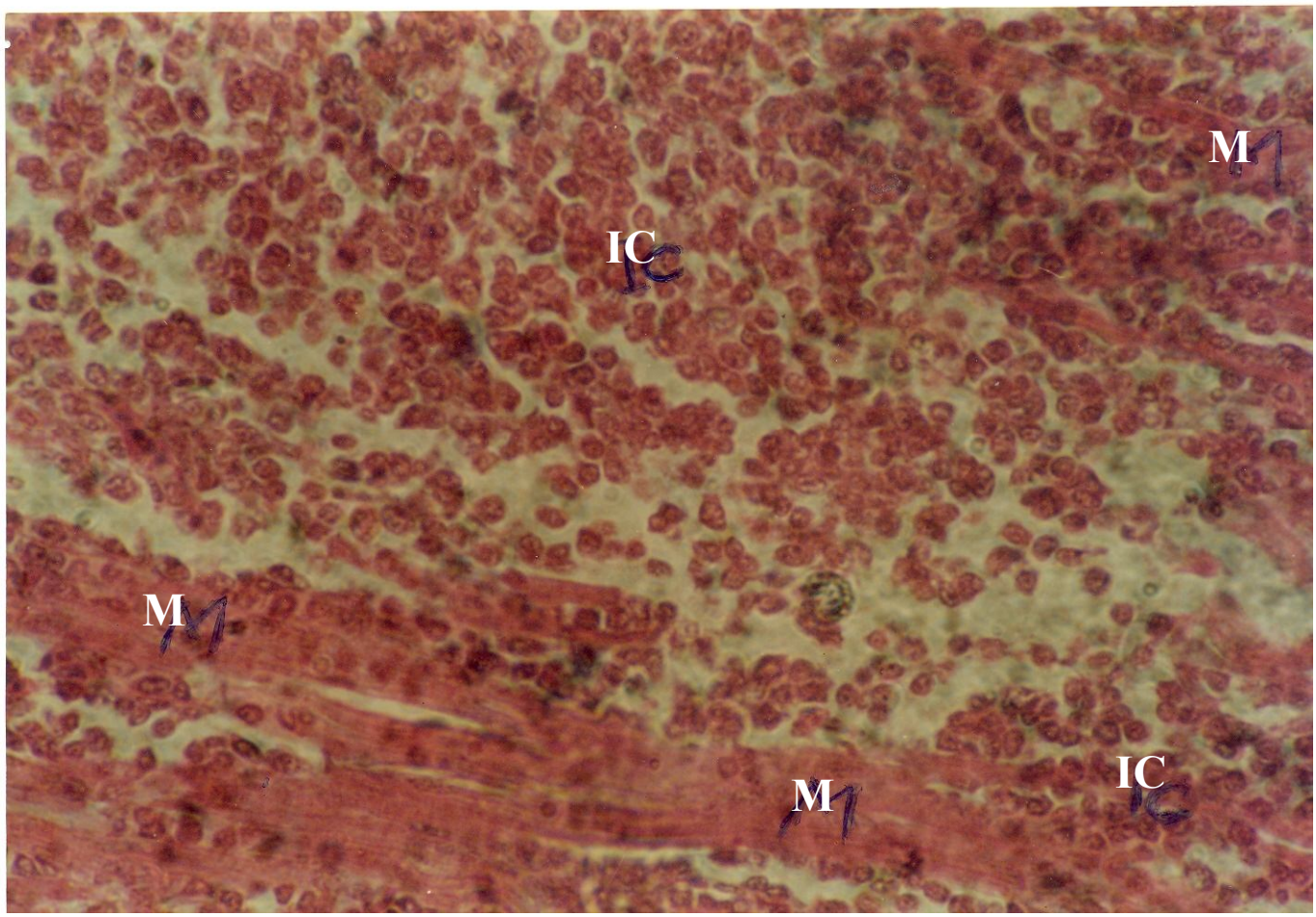


Plate XXV: Photomicrograph of a section of heart from an infected pigeon, showing the necrosis of the myocardial cells (M) and the inflammatory cellular infiltration (IC). H&E Stain. X1000

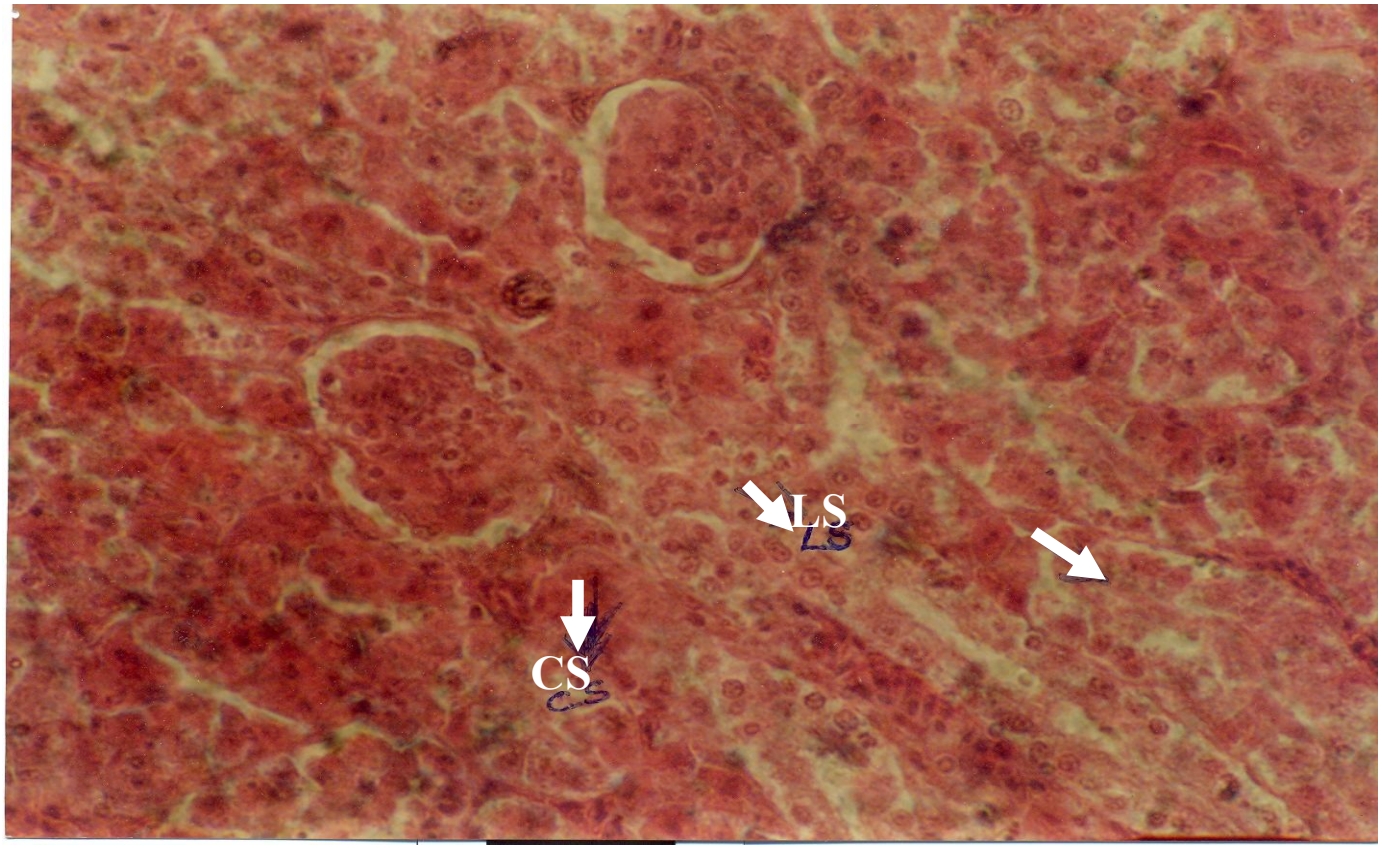


Plate XXVI: Photomicrograph of a section of kidney from an infected pigeon, showing the renal tubular necrosis (arrow heads). H&E Stain. X400

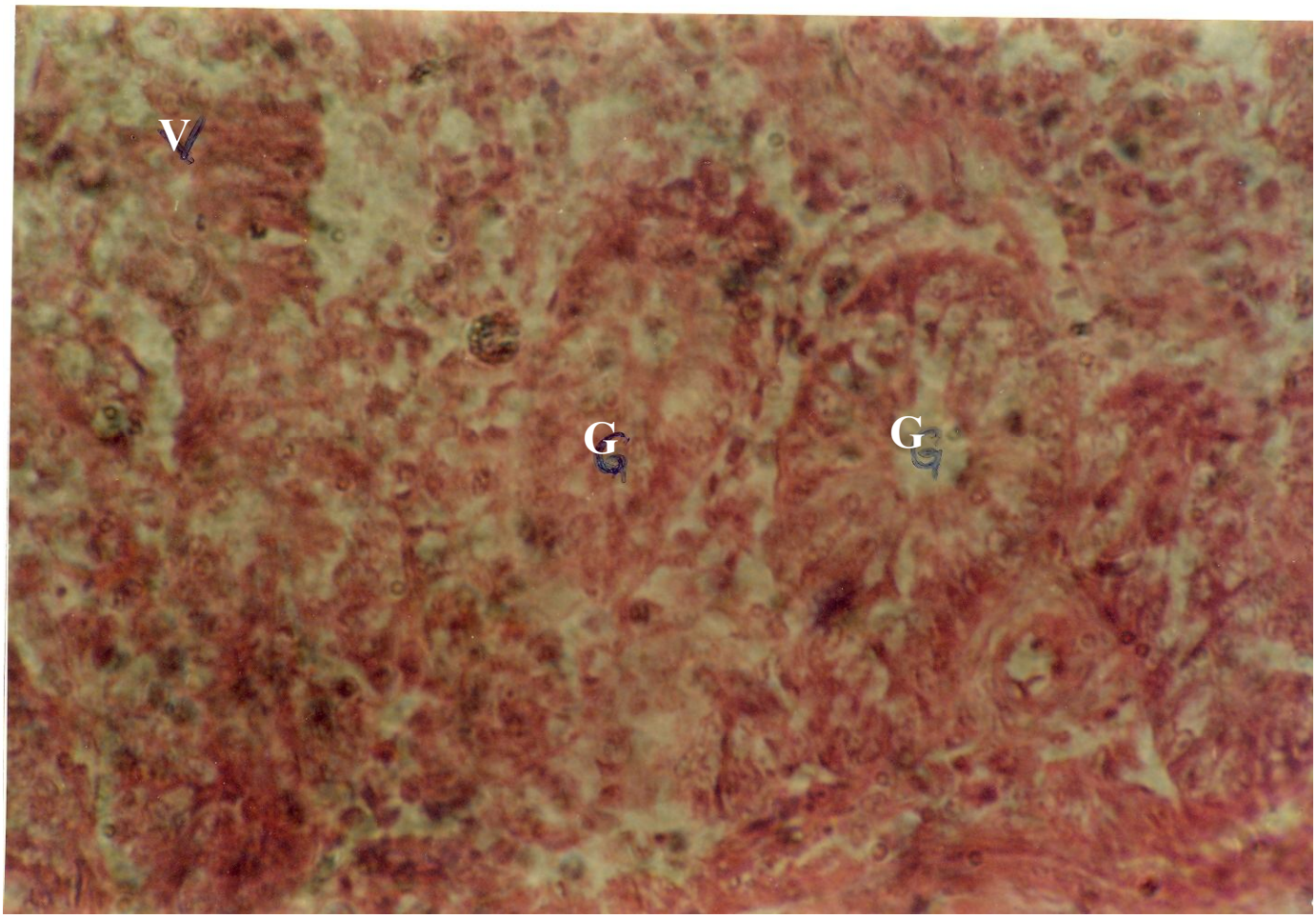


Plate XXVII: Photomicrograph of a section of intestine from an infected pigeon, showing necrosis of the intestinal villus (V) and intestinal glands (G). H&E Stain. X400

CHAPTER 5 DISCUSSION

5.1 **Ectoparasites of Columbids**

5.1.1 *Prevalence of ectoparasites on Columbids*

The most important ectoparasites of pigeons and doves in the present study are insects and arachnids. They parastise various parts of the Columbids, and their respective prevalence varied from species to species. For instance, a prevalence of 73.8% found in Domestic Pigeon in this study appears to be high compared to 72.0%, 50.0% and 30.0% found in Domestic Pigeons by Senlik *et al*. (2005), Mushi *et al*. (2000) and Petryszak *et al*. (2000) respectively. Variations in the number of birds examined as well as in the climatic conditions prevailing in the study areas may account for the differences in the prevalence of ectoparasites. Host body size has been known to influence ectoparasite infestations, since ectoparasites seem to prefer large body size hosts to hosts with small body sizes (Bush and Clayton, 2006). This may have accounted for the highest prevalence (73.8%) of ectoparsites on Domestic Pigeon compared to Speckled Pigeon (64.3%), Mourning Dove (54.2%), Laughing Dove (23.0%), Black-billed Wood Dove (21.9%) and Vinaceous Dove (33.3%). The Domestic Pigeons usually form large flocks and are also gregarious, these attributes may have increased the contact between individuals, thereby enhancing the intra-specific transfer of ectoparasites especially lice (*M. gallinae*, *C. columbae*, *Goniodes* sp.). Furthermore, under domestication, there is relatively greater contact between individuals particularly as they are raised commercially and therefore stocking density may be high, thus pointing to the fact that domestication favours intra-specific transfer of ectoparasites, enhancing higher prevalence of ectoparasites in Domestic Pigeon.

Some of the ectoparasites recovered from the Columbids namely *M. gallinae*, *Goniodes* sp., *D. gallinae* and *A. persicus* have been reported on poultry in Zaria (Abdu *et al.,* 2002). It is therefore

likely that the Columbids might have acquired these parasites from domestic poultry particularly as some of the Columbids nest and roost around human dwellings where poultry are raised. Columbids may therefore serve as reservoirs to these parasites.

Five ectoparasite species were recovered from Domestic Pigeon, six from Laughing Dove, and three species from Mourning Dove, Speckled Pigeon, Black-Billed Wood Dove, and Vinaceous Dove, compared to nine by Conti and Forrester (1981), five by Rosciszewska *et al*. (1996), two by Mushi *et al*. (2000), two by Petryszak *et al*. (2000), two by Dovc *et al*. (2004), five by Foronda *et al*. (2004) and three by Senlik *et al*. (2005). Diversity of bird ectoparasite assemblages may be related to many factors, which may include home range, behaviour, size and roosting habit of the host. The high ectoparasite diversity on Domestic Pigeon and Laughing Dove in this study could be due to the fact that they exploit a wider range of ecological niches (home range) for feeding, roosting, nesting and territoriality, than the other Columbids, from where they can come in contact with ectoparasites (Goodwin, 1983). Their relative closeness to human dwellings may afford them the possibility of acquiring ectoparasites from domestic poultry.

All the ectoparasites (*M. gallinae*, *C. columbae*, *Goniodes* sp., *P. canariensis*, *A. persicus*, *D. gallinae*) reported in the present study have been reported on Columbids, especially Domestic Pigeon, by previous researchers in other parts of the world (Davis *et al*., 1971; Nelson and Murray, 1971; Cheng, 1973; Pilgrim, 1976; Soulsby, 1982; Yavornitskii and Kharambura, 1982; Arends *et al*., 1984; Conti and Forrester, 1981; Rosciszewska *et al*., 1996; Mushi *et al*., 2000; Petryszak *et al*., 2000; Dovc *et al*., 2004; Foronda *et al*., 2004; Senlik *et al*., 2005), confirming the fact that these are common ectoparasites on Columbids. Some of these previous researchers however reported on other ectoparasite species on Columbids, which were not observed in the present study. This may be due to the fact that the prevailing climatic conditions in the study area were

unfavourable to some of the parasites not encountered. Five of the six Columbids examined were wild species and these parasites may not be very common in the wild species of Columbids. Although these parasites are common to Columbids, they may be restricted to particular geographical regions that favour their growth and survival.

No new host records were observed for ectoparasites since all the ectoparasites recorded have been reported on Columbids especially Domestic Pigeon (*Columba livia domestica*) and Rock Dove (*Columba livia*). However, no information on the ectoparasites of the other Columbids examined in this study in Nigeria is available to the author, therefore this study may be the first report of such ectoparasites on them.

The ectoparasites were found to parasitise various parts of the Columbids. *M. gallinae* and *Goniodes* sp., parasitised the head, neck and body, *C. columbae* the quill feathers of the wings and tail, *P. canariensis* the down and contour feathers of the skin, *A. persicus* the thigh and wing web and *D. gallinae* the body and legs. Similar findings were reported by other researchers (Fabiyi, 1988; Nfor, 1998) for *M. gallinae*, (Nelson and Murray, 1971; Pilgrim, 1976) for *C. columbae*, (George and Abdu, 1989) for *P. canariensis*, (Hoogstraal *et al*., 1977; Siuda *et al*., 1979) for *A. persicus* and (Yavornitskii and Kharambura, 1982) for *D. gallinae*. Rothschild and Clay (1952) and Nfor (1998) reported ticks on the ear, eye, wattles and rump of birds. All these reports are suggestive of the fact that ectoparasites are often specific to a particular part of the pigeon's body, particularly where the bird's bill cannot reach during preening, thus reducing the possibility of being removed or dislodged during the process of preening or grooming (Marshall, 1982).

5.1.2 *Intensity of ectoparasite infestations on Columbids*

In the present study, the ectoparasites showed an over-dispersed distribution in all the Columbids examined, where "many birds harboured few parasites while a few birds harboured many parasites". This result agrees with the report of Geets and Ollevier (1996) that over-dispersed distribution of parasites within the hosts ensures that infestation is kept at low level with a few hosts becoming heavily infested.

Similar results were obtained by Keymer *et al*. (1962) who reported that only nine out of the 2,044 birds examined, carried an ectoparasite burden that could be considered pathogenic. Many parasites never appear under natural conditions, to reach a level at which they can kill their hosts since killing the hosts may be a potential danger to the parasite. Birds with straight bills such as the Columbids have been found to be very effective in removing ectoparasites (Clayton and Cotgreave,

1994). Thus, in the process of grooming themselves, these birds remove infesting ectoparasites, thus regulating the ectoparasite population (Petryszak *et al*., 2000).

5.1.3 *Frequency distribution of single and mixed infestations*

Prevalence of mixed infestations was higher than that of single infestations in Domestic Pigeons, Mourning Dove, Speckled Pigeon and Vinaceous Dove while the prevalence of single infestations was higher than that of mixed infestations in Laughing Dove and Black-billed Wood Dove. Similar findings of mixed infestations being higher than single infestations have been reported by Rosciszewka *et al*. (1996), Petryszak *et al*. (2000), Mushi *et al*. (2000) and Senlik *et al*. (2005). It is probable that ectoparasites can cohabit or coexist without causing any harmful effects on each other (Mettrick and Podestra, 1974). Locational preference or specificity for particular microhabitats on the host, as well as differences in metabolic, physiological or nutritional requirements may have facilitated the coexistence of multiple parasites species on the same host (Cheng, 1973).

5.1.4 *Sex-related ectoparasite infestations of Columbids*

The sex ratio in the sampled Columbid population showed that more males (430) than females (306) were examined. Domestic Pigeon breeders prefer to sell the males rather than the females, which are reserved for breeding purposes. Male pigeons provide nesting materials, guard the females and the nests, thus may be more vulnerable to trapping than the females. The prevalence of ectoparasites in females (44.8%) was slightly higher than in males (42.1%). The females lay and incubate the eggs, during this waiting period, they may be susceptible to ectoparasite infestation. A higher number of ectoparasites were recovered from males (57.8%) than from the females (42.2%) and mean intensity in males (16.0±0.80) was higher than in females (15.4±0.79). However, Chi

square tests showed that the differences were not significant, suggesting that both sexes are equally exposed to ectoparasite infestations. This result is in accordance with those of Rosciszewska *et al*. (1996), Petryszak *et al*. (2000) and Senlik *et al*. (2005). A flock of pigeons usually consists of equal numbers of males and females giving credence to the point that both sexes are equally exposed to the acquisition of ectoparasites (Goodwin, 1983).

5.1.5 *Effects of ectoparasite infestations on body weight and PCV of Columbids*

Ectoparasite infestation had no effect on body weights and PCV values since there was no significant difference in the mean body weights and PCVs of infested and uninfested birds. This may be related to the fact that the birds examined were apparently healthy and none of them carried an ectoparasite burden that could be considered pathogenic to have had any significant effects on body weights and PCV values. But it is however a well known fact that some ectoparasites such as *Argas persicus* suck blood resulting in blood loss and others cause irritation leading to excessive preening and weight loss. Other transmit haemoparasites.

5.1.6 *Monthly prevalence of ectoparasites on Columbids*

The occurrence of ectoparasites on Domestic Pigeon and Laughing Dove in all the months of the year and in all or most of the months for which Mourning Dove, Speckled Pigeon, Black-billed Wood Dove and Vinaceous Dove were sampled, shows that the birds may harbour or may be exposed to ectoparasite infestations throughout the year or most of the year. Although the prevalence in the wet season was higher than that of the dry season, in Domestic Pigeon and

Laughing Dove, the difference was not significant (P>0.05), confirming the earlier view that the birds may be exposed to ectoparasite infestations throughout the year.

The peak infestation month was August for Domestic Pigeon, which coincides with the peak rainy (cold wet) season in Zaria with ambient temperature of 23.30°C, rainfall of 314.3 mm and a relative humidity of 70-80% (Hore, 1970). Senlik *et al*. (2005) also observed highest infestation of ectoparasites on Domestic Pigeon in summer which coincide with the rainy season in Zaria. The association of ectoparasite infestation with the rainy season probably shows that the rainfall favours ectoparasite infestation. The climatic conditions within the rainy season may therefore be conducive for the multiplication or reproduction of most of the ectoparasites, leading to the high prevalence and intensity observed. Breeding in Columbids occurs in any month of the year (Goodwin, 1983), but may be synchronized to coincide with the rainy season when there is an abundance of animal material (insects) with which to feed their young. Breeding at this period may enhance intra-specific transfer of ectoparasites between mating pairs, and from parents to off-spring and this may have accounted for the higher prevalence observed during the rainy season compared to the dry season (Boyd, 1951; Lee and Clayton, 1995). The peak infestation was in November in Laughing Dove, which coincides with the early dry season in Zaria. This probably attests to the fact that the climatic conditions prevailing within this month are favourable for the growth, maturity and reproduction of these parasites. The month of November also marks the start of harvest of cereals (grains) in Zaria and the Laughing Doves usually come out in large flocks to feed on seeds that spill during harvest. This may expose them to the acquisition of a variety of ectoparasites or may enhance intra- specific transfer of ectoparasites during this period.

The recovery of *M. gallinae* in only six months of the year in Domestic Pigeon shows that the parasite does not occur on the birds in all the months of the year. *Menopon gallinae* has been reported on guinea fowls (Nfor, 1998) and on poultry (Agbede, 1981) in Zaria. The parasite may therefore be found on these hosts when it is absent on Domestic Pigeon. The absence of *M. gallinae* in the months in which *Goniodes* sp. was prevalent may be an innate strategy of avoiding competition (Anderson, 1974). The observation of *M. gallinae* in eleven months of the year in Laughing Dove shows that it is the most common and most prevalent ectoparasite of Laughing Dove. The implication is that Laughing Dove may be exposed to infestation with this parasite in almost all months of the year irrespective of the prevailing climatic conditions. Such conditions may as well favour the growth, maturity and breeding of the parasite. But the low prevalence observed in most of the months may be due to the low host specificity of *M. gallinae* such has been reported on poultry (Agbede, 1998; Nfor, 1998), and may tend to seek these alternative hosts (poultry) which are readily available for infestation than Laughing Dove. The recovery of *M. gallinae* from Mourning Dove, Speckled Pigeon, Black-billed Wood Dove and Vinaceous Dove in all the months in which they were sampled shows that it is a common ectoparasite of wild Columbids in Zaria.

Columbicola columbae and *Pseudolynchia canariensis* are ectoparsites of Domestic Pigeons through out the year. This is an indication that the parasites are capable of growing, maturing and reproducing on the host at all times of the year irrespective of the prevailing climatic conditions, and can be transmitted from one generation of host to another. Pilgrim (1976) reported that *C. columbae* breeds all year round on *C. livia* and also found no pronounced seasonal changes in prevalence and intensity. The highest prevalence of the parasites in August and higher prevalence and association of the parasites with the wet season, show that though birds may be infested by the

parasites in all months of the year, infestation may be higher in August and in the wet season. *Columbicola columbae*, may therefore be the cause of pediculosis or lousiness in Domestic Pigeon and *P. canariensis* the cause of avian malaria, especially in August or wet season. A fairly stable equilibrium was maintained in the prevalence of *C. columbae* and *P. canariensis* infestation on Domestic Pigeon. The interaction of the two ectoparasites on Domestic Pigeon may be said to be a low inter-specific competitive interaction characterized by simultaneous infestation that is not detrimental to the two species. It is also likely that the dietary demand and behaviour of the parasites differ thereby enabling close interaction or cohabitation. Therefore it is likely that the two ectoparasites did not confer resistance against each other, neither were they competing. When their prevalence in August was high, the other ectoparasites were basically absent, though there were over laps of infestation in other months.

Columbicola columbae was identified on Laughing Dove in ten months of the year. As a permanent parasite that spends its entire life on the host and also being highly host specific to the Columbids, *C. columbae* is likely to be found on Laughng Dove at all times of the year. The recovery of *C. columbae* from Mourning Dove, Speckled Pigeon, Black-billed Wood Dove in all the months in which sampling was carried out and in one month from Vinaceous Dove, suggests that it is the most prevalent ectoparasite on wild Columbids in Zaria.

Therecovery of *P. canariensis* from Laughing Dove in seven months of the year and from Mourning Dove and Speckled Pigeon in all the months in which sampling was carried out and from Vinaceous Dove in one out of the three months in which sampling was carried out shows that it is a prevalent ectoparasite on wild Columbids in Zaria. Its absence on Black-billed Wood Dove may have been incidental.

Goniodes species was found on Domestic Pigeon in seven months of the year and on Laughing Dove in four months, making it a common parasite to these Columbids. The parasite was however not recovered from the other Columbids. *Goniodes* sp. seemed to be absent in most of the months during which *M. gallinae* was prevalent. This is probably due to the fact that the two parasites share the same locational and nutritional niches on the host. *Goniodes* sp. has also been reported on chicken (Agbede, 1981) and guinea fowl (Nfor, 1998). The absence of the parasite in a greater part of the year probably indicates that at such times, the parasite may seek other hosts.

The presence of *A. persicus* in only three months of the year on Laughing Dove, shows that it is a common parasite on Laughing Dove. Its highest prevalence in August may be a possible indication that infestation with the parasite is favoured by high rainfall, moderate temperature, and high relative humidity which prevail in the month of August. The result agrees with that of Hoogstraal *et al.* (1977) who reported that tick infestation is favoured by warm, humid conditions, which prevail in August in Zaria. The wet season probably represents the larval (stage) season of *Argas persicus* in Zaria. In a study conducted by Nosek *et al.* (1980), larval hatch from spring to autumn and nymphal and adult molting occurred chiefly in July and August. The relative or numerical abundance of ticks varied between the larval and nymphal season. The average tick burden ranged from 134.9 per bird during the larval season to 29.0 per bird during the nymphal season.

Ticks may therefore develop and reproduce during the warm season in the wild.

Argas persicus was the most prevalent in the months it appeared showing that it probably avoids competition or cohabitation with other ectoparasites on the same hosts (Kennedy, 1975a). This is further supported by the fact that no mixed infestation was observed between *A. persicus* and the other ectoparasites.

Actually adult *A. persicus* is an intermittent ectoparasite, found as a temporary parasite on the host only during feeding. The parasite remains inactive in cold weather and only lays eggs in warm weather (Soulshy, 1982). *Argas persicus* was observed in two months on Black-billed Wood Dove, this shows it is a common ectoparasite of Black-billed Wood Dove in Zaria. As *Argas persicus* usually reproduces in warm humid climate and this may be attributed to its absence in December and January, which are the peak months of Hamattan (dry-cold period) in Zaria.

Argas persicus was recovered in Black-billed Wood Dove in February and March and in July, August and October on Laughing Dove, indicating that the warm-humid conditions prevailing in these months may also favour tick reproduction. These months may also coincide with the larval stage of the parasite since only tick larvae were also collected. The parasite on Black-billed wood Dove is associated to the dry season as opposed to its association to the wet season on Laughing Dove.

Dermanyssus gallinae was found in four months of the year on Domestic Pigeon and one month in Laughing Dove. Actually *D. gallinae* is an intermittent ectoparasite that is found temporarily on the host only during feeding and the parasite spends only about 2 to 4 hours on the host, takes a blood meal and then drops into cracks and crevices in the nest or pigeon loft and remains inactive there until when another blood meal is to be taken then can it mount the host again. The parasite remains inactive during cold weather and only lays eggs in warm weather (Soulsby, 1982). This probably accounts for its high prevalence in May. *Dermanyssus gallinae* has been reported on poultry in Zaria and it is likely that the parasite may seek other hosts in the months it is absent on Domestic Pigeon and Laughing Dove (Abdu *et al*., 2002).

The presence of ectoparasites on Columbids may have varied implications on the health and productivity of the birds and also on man and /or his domestic animals.

Intense irritation caused by bites and movement of ectoparasites such as *M. gallinae*, *C. columbae*, *Goniodes* sp., *P. canariensis*, *A. persicus* and *D. gallinae*, may affect the health and productivity of the birds due to stress, excessive preening, low feed consumption and loss of condition (Schillhorn van veen and Mohammed, 1975). The consumption of host blood by *M. gallinae, P. canariensis, A. persicus* and *D. gallinae* may lead to anaemia and increased mortality in the birds (Booth *et al*., 1993). Punctures made in the feathers by *M. gallinae C. columbae* and *Goniodes* sp. may hinder further development of the feathers and may interfere with their thermal regulation (Soulsby, 1982). The transmission of pathogens such as *Chlamydia* sp. that causes ornithosis by *Menopon gallinae*, *Haemoproteus columbae*, *Plasmodium* spp and *Leucocytozoon* spp., *Staphylococcus aureus*, *Streptococcus epidermidis*, *Candida albicans* and pox–virus by *Pseudolynchia canariensis* (Lapage, 1961; Kemp, 1978; George and Abdu, 1989), spirochaetosis, piroplasmosis, anaplasmosis, dirofilariasis, certain reckettsial diseases and many viruses e.g. encephalitis (Soulsby, 1982) by *Argas persicus* and *Borrelia anserina* the cause of spirochaetosis, *Lankesterella garnhami* and the virus of EEE (Laison, 1960) by *D. gallinae* may have various debilitating effects on the health and productivity of the birds. *Pseudolynchia canariensis* may bite humans inflicting a painful wound while itchings and dermatitis may result from attacks of humans by *A. persicus* and *D. gallinae* (Soulsby, 1982).

5.2 **Helminths of Columbids**

5.2.1 *Prevalence of helminths in Columbids*

The prevalence (48.3%) recorded in this study for Domestic Pigeon is lower than 62.5% recorded by Dede and Richards (1998) and 86.0% by Atsineka and Banke (2006) but higher than 43.4% recorded by Audu *et al.* (2004). While the prevalence of 57.9% obtained in this study for Laughing Dove is higher than the 44.0% reported by Gadzama *et al.* (2005) but lower than the 69.2% recorded by Oniye *et al.* (2000a). The prevalence of 60.4% observed in this study for Mourning Dove is lower than the 100.0% reported by Dede and Richards (1998). The prevalence of 60.7% in this study for Speckled Pigeon is lower than the 75.0% recorded by Dede and Richards (1998). The prevalence of 43.8% and 50.0% recorded in this study for Black-billed Wood Dove and Vinaceous Dove respectively shows that these Columbids are parasitised by helminths. The differences in prevalence of helminths obtained in the present study and those of these previous workers could be linked to the food and feeding habits of the Columbids (Adang, 1999), availability and abundance of intermediate hosts or infective stages of the parasites (Cheng, 1973), the altitude and prevailing climatic conditions within the study area, as well as the number of birds examined. While this study was continuous for 24 months, others studies were intermittent or restricted to a few discontinuous months. The diets of birds have been known to a great extent to determine the composition of their parasitic fauna (Malhotra and Capoor, 1980). Pigeons feed on grains of all kinds as well as on insects and other invertebrates (Adang, 1999), which may carry infective stages of these parasites, there by serving as intermediate hosts to the Columbids (Mushi *et al*., 2000).

Some of the helminths identified in the present study (*R. tetragona*, *R. echinobothrida*, *R. cesticillus*, *A. cuneata*, *H. carioca*, *A. galli* and *A. columbae*) have been reported in Columbids in previous researches conducted in Zaria, Nigeria, and in other parts of the world (Barrows *et al*., 1977; Olsen and Braun, 1980; Conti and Forrester, 1981; Mushi *et al*., 2000; Glass *et al*., 2002; Dovc *et al*., 2004; Foronda *et al*., 2004; Bean *et al*., 2005; Senlik *et al*., 2005). However, *R.*

magninumida, *H. cantaniana* and *Heterakis gallinarum* reported in this study have not been reported in pigeons in Zaria or other parts of the world. This may be an evidence of new host records for these parasites. Differences in the diversity of helminth species found may be attributed to the number of birds examined and to the habitat or ecological niche where the present study was conducted.

Lower prevalence of nematodes compared to cestodes was obtained in this study. This is in line with similar reports by Dede and Richards (1998), Audu *et al.* (2004) and Arnall and Keymer (1975). This suggests dissimilarity in the mode of infection of both groups of parasites, and indicative of low environmental contamination by infective eggs or larvae of nematodes. It is also possible that there is no direct feeding link between the nematodes and the Columbids as it is the case with cestodes in which their intermediate hosts form an important part of the diets of Columbids. Most of the nematodes infecting Columbids have a direct life cycle and so there is low probability of the parasite locating its host (Kennedy, 1975a). The low prevalence of nematodes may also be due to changes in host's diets, ecology, age and host response, because birds generally invoke immunological responses to parasites, leading to low prevalence or elimination of the parasites in the host (Kennedy, 1975a).

It is likely that the environment from which the birds were trapped or captured was not contaminated by infective nematode eggs. The fact that only Domestic Pigeon and Laughing Dove were infected by nematodes confirm this fact, because they are about the only Columbids that are close to human habitation that may be contaminated with nematode eggs from poultry faeces.

The cestodes, *Raillietinia* spp. (*R. tetragona*, *R. echinobothrida*, *R. cesticillus* and *R. magninumida*), which were the most dominant helminths in this study, are known to be cosmopolitan and contribute to nutrient depletion in birds (Cheng, 1973). Ants of the genera *Pheidole* and *Tetramorium* were reported to serve as intermediate hosts in the transmission of *Raillietina* spp. (Soulsby, 1982). Since these ants together with beetles, termites, flies and other arthropods, in addition to seeds form a major part of the diets of pigeons (Adang, 1999), it is therefore likely that the birds might have acquired the helminth infections from their diets. Many larvae and adults of grain insect pests such as *Tenebrio* and *Tribolium* spp., are implicated as intermediate hosts of *Hymenolepis* spp. Some of the helminths recovered in this study were also reported in poultry (Abdu *et al*., 2002) and in other wild birds (Oniye *et al*., 2000b), and outside the study area. This is an indication of a wide distribution of the parasites across different hosts and geographical zones. Such parasites are therefore said to be polyphagous (Kennedy, 1975b).

The predilection site for all the helminths in this study was the small intestine, particularly the duodenal loop and ileum. Only *Heterakis gallinarum* resides in the caeca. The restriction of helminths to the intestinal and caecal regions is an indication of site specificity. This implies that these areas present a nutritionally rich and conducive environment for the parasites. For instance, cestodes do not have guts and would therefore live in an environment in which food is readily available in a digested form, ready for absorption, such as in the intestine. The findings of this study also concur with the suggestion of Crompton (1973), that the attachment sites of adult helminths are limited to the intestinal regions that are specialized for absorbing nutrients. Such site preference has been explained as being greatly determined by the degree of saline and glucose concentration and other metabolic requirements such as semi digested food and debris, optimum to the parasite (Symth, 1994; Frantova, 2000).

Cestodes are generally known to interfere with carbohydrate metabolism, as they absorb glucose and galactose from their hosts which are stored as glycogen (Read, 1959). Amino acids, dipeptides, polypeptides and entire proteins, are also known to be actively absorbed by cestodes (Cheng, 1973). The complete absence of *H. gallinarum* in parts of the host where cestodes abound could suggest a behavioural adaptation to evade interspecific competition amongst parasites (Kennedy, 1975b).

5.2.2 *Intensity of helminth infections in Columbids*

The very low range of infection observed in this study for each of the helminths, concurs with the reports of Dede and Richards (1998), Oniye *et al.* (2000a) and Audu *et al.* (2004). This could be due to the fact that many parasites never appear under natural conditions to reach a level that could kill their hosts. Overwhelming infection of host would always be a potential danger to the parasite, for no population over exploiting it resources is likely to survive. If the parasite burden in a host rises above a threshold value, then the host may respond to the parasite immunologically, causing a variety of effects upon the parasite, including expulsion of all or part of them from the host, reduced egg production and retardation of larval development. Low parasite burdens would however be tolerated and would not evoke such reponses. The threshold tolerated and the vigour of the response varies between individuals of the same species and between hosts of different species (Kennedy, 1975a). This depends upon the pathogenecity of the parasite and on the conditions and suitability of the host (Kennedy, 1975a). Within a population, hosts may show genetically based variations in susceptibility to parasitic infections Kennedy, 1975b). Thus, some hosts are capable of harbouring high parasite population while others cannot. Nevertheless, heavily infected hosts may be killed by the parasite or become easily susceptible to predators (Kennedy, 1975b).

5.2.3 *Frequency distribution of single and mixed infections*

This study shows that single infection was higher, than double infection, and triple infection was the least. This gradation in manner of infection suggests either that food consumed at a particular time may determine the establishment of single or mixed infection; or that the first parasite to arrive at a favourable site quickly reproduces and occupies space thereby inducing a host response which may prevent the establishment of others. Furthermore, host's diet may determine the establishment of single or mixed infections among helminths (Crompton, 1973). Gause's law of competitive exclusion principle states that "complete competitors cannot coexist". If two populations of the same species attempt to occupy the same niche, eventually, either one will replace the other or their characteristics will change, such that their niches no longer over-lap (Crompton, 1973). This may account for the low prevalence of double and triple infections between the cestodes, which probably have the same nutritional niches, in Domestic Pigeon and Laughing Dove; and the total absence of mixed infections in Mourning Dove, Speckled Pigeon, Black-billed Wood Dove and Vinaceous Dove.

However, it is possible for two different species of parasites to occupy the same habitat while occupying different nutritional niches, because one utilizes glucose as a nutritional substance whereas the other utilizes fructose (Kennedy, 1975a). This may account for the mixed infections between cestodes and nematodes and between *Raillietina* spp. and *Hymenolepis* spp. observed in Domestic Pigeon and Laughing Dove.

It is likely that the dietary demand and behaviour of the parasites in the gastro-intestinal tract differ, thereby enabling close interaction. Kennedy (1975b) concluded that inter-specific

competition can occur and is usually detrimental to one or both species but is of fairly rare occurrence and little significance in controlling the size and diversity of parasite populations.

Dede and Richards (1998) found single infection to be the highest, then double infections and triple infection as the least. Audu *et al.* (2004) however reported double infection to be highest, then single infections and triple infections as the least. Atsineka and Banke (2006) reported mixed infections to be higher than single infections. Single infection seem to be more favoured than mixed infection, though it may appear as if there is no definite pattern of infection, and infection may be single or mixed.

5.2.4 *Sex-related helminth infections in Columbids*

In Domestic Pigeon, Mourning Dove and Black-billed Wood Dove, the males were more infected by helminths than the females, while the reverse was the case in Laughing Dove, Vinaceous Dove and Speckled Pigeon. These differences were statistically insignificant, indicating that both males and females are equally exposed to the acquisition of helminth infections particularly as their feeding and food habits are not different. Columbids of both sexes generally move and feed together, thus they are exposed equally to infective eggs and intermediate hosts of these parasites. Glass *et al*. (2002) stated that the sex of doves had no effect on the abundance of helminths and that this is consistent with the fact that doves of both sexes use the same habitat in breeding duties in the same manner.

The physiological differences between males and females did not appear to affect the susceptibility of birds of both sexes to infection. The difference in prevalence of helminths between the males and females may be incidental due to the higher number of males sampled than females. It is likely

that the higher prevalence rate in females as to males observed in Laughing Dove, may be due to the fact that females appear to consume larger amounts and varieties of animal food-organisms than the males, because female birds expend more energy than males in the reproductive process, and that relative large amounts of animal materials consumed by the females are vital for egg formation, as well as for accumulation of body fats that are used during incubation and chick rearing (Welty and Baptista, 1990). Therefore the differences in the parasite incidence may imply that a single cause such as sex may not be responsible for distribution of parasites but rather a combination of other factors.

5.2.5 *Effects of helminth infections on body weight and PCV of Columbids*

The non-significant difference between the mean body weights and PCV values, of infected and uninfected birds may indicate that none of the infected birds actually carried a parasite burden that could be considered pathogenic to affect their body weights and PCV values. The failure to detect a significant detrimental effect of parasitism on body weights and PCV values is not an indication that such detriment did not occur but rather that host factors which affects both body weights and PCV values could not be quantified in this study. Such factors include dietary parameters, health practices, previous infection levels and bird genetics. The birds examined in this study were mature and healthy birds and these may be the reasons for the non-significant effects of the parasites on body weights and PCV values.

Hosts may partially circumvent the negative effects of parasites by compensatory activities (Moller, 1993). These activities may include increased consumption of food and compensatory increments of the mucosal area, among individuals heavily infected by intestinal parasites (Przystalski, 1988). If food is readily available, this may lead to complete compensation on the part of the host and the negative effects of the parasites on their hosts may then be virtually absent.

The onset of recognizable disease symptoms is dependent upon the presence of a sufficient number of parasites as well as the physiological state of the host. Thus, in many instances, no clinical signs may be apparent when small number of parasites are present. The severity of the parasitic infection is determined by the type of parasite involved, predilection site, dose of the parasite, age, physiological and immune state of the host
(Kennedy, 1975a). Most of the helminths encountered in this study have mild to moderate pathogenicity which had no significant effects on body weight and PCV values of infected birds (Hofstad *et al*., 1984).

5.2.6 *Monthly prevalence of helminths in Columbids*

In all the Columbids, it is evident that the birds were exposed to helminth infections throughout the year suggesting that the infective stages of the helminths are available through out the year. Kennedy (1975a) suggested that there is clearly no sharp distinction between seasonal and non-seasonal prevalence cycles and intermediate stages on the cline between them may occur when local conditions restrict infection periods or parasite maturation. The minor differences in the prevalence rates of the parasites within months could be due to the availability and relative abundance of their intermediate hosts, or infective stages.

The peak infection (80.0%) months were June and July in Domestic Pigeon, August (83.3%) in Laughing Dove, May (76.5%) in Mourning Dove, June (83.3%) in Speckled Pigeon and May (100.0%) in Vinaceous Dove. These periods coincided with the beginning of the rains/rainy season when insects, on which the pigeons feed are abundant. This is an ecological synchrony which allows the survival of certain organisms while others die. Furthermore, it is possible that during

this period, the rains may wash away the surface soil to expose the nematode eggs hidden below for the birds to ingest, and also bring about the availability and abundance of insects, which serve as intermediate hosts to the cestodes. Farming activities in Zaria during the early months of the wet season may also help in exposing nematode eggs hidden below the surface soil for the birds to ingest particularly as the birds visit newly cultivated farms in large flocks to feed on spilled grains during planting. During the rainy season, the birds eat more of animal materials termites, earthworms, *Papilio* larvae, *Polyxus* sp. and ants than seeds (Rowan, 1983). Insects (arthropods) and other invertebrates, which serve as intermediate hosts of some helminths are available and more abundant in the wet season and form a greater part of the diets of the birds (Adang, 1999). In addition, during the wet season, the seeds of wild plants on which the Columbids feed would have germinated, while cultivated cereals are yet to mature. The only seed that the birds can feed on may be those of stored grains, most of which may contain stored-grain insect pests, which also serve as intermediate hosts of some cestodes (Malhotra and Capoor, 1980). The birds now resort to feeding on insects and other invertebrates from which they can acquire helminth infections.

Calentine and Fredrickson (1965) suggested that the lack of a seasonal periodicity in infections with helminths was related to the year round availability of ants and annelids. The cysticercoids of cestodes do not cause any apparent damage to their ants or annelids intermediate hosts. If the cysticercoids are small and non-pathogenic to their intermediate hosts, then the year round availability of cystcercoids, allowing for continuous recruitment, may explain why some helminths were recovered in all the months of the year, and thus lack of seasonal periodicity.

Pearson correlation coefficient using the meteorological data collected from Institute of Agricultural Research (IAR) Samaru, showed a significantly positive correlation between rainfall

and helminth infections, a significantly negative correlation with maximum temperature, a significantly positive correlation with minimum temperature and relative humidity, indicating that the wet season actually favours helminth infections.

The harsh and unfavourable climatic conditions such as low relative humidity, extreme cold and high temperatures and no rainfall that characterize the dry season in Zaria, might have brought about the low population of invertebrates hosts and negatively affected the viability of oncospheres of cestodes, resulting in the low infection rates and worm loads in the dry season. This probably explains the reason for the significantly negative correlation between maximum temperature and helminth infections in Domestic Pigeon. Seasonal inducing factors may operate to produce slight peaks in prevalence or produce well-defined cycles in both prevalence and intensity of infection (Kennedy, 1975a). It is likely that the climatic conditions prevailing within the months of low helminths diversity did not favour the survival of the intermediate hosts of most of the parasites, or the intermediate hosts of these parasites were unavailable or less abundant during such months.

The presence of helminths in the gastro-intestinal tract of Columbids may have various implications on the health and productivity of the birds. Of the seven species of cestodes recovered from the Columbids in this study, *R. echinobothrida* is the most pathogenic (Hofstad *et al*., 1984). Intestinal nodules at the site of attachment of *R. echinobothrida*, and hyper plastic enteritis have been reported (Soulsby, 1982). *Raillietina tetragona* shows moderate to serve pathogenicity and may sometimes cause nodule formation. Emaciation and death may occur in young birds while adult birds show decrease in production (Soulsby, 1982). *Raillietina cesticillus* may in heavy infections cause emaciation and at the point of rostellar attachments, causes degeneration and inflammation of the villi (Cheng, 1973).

Pathogenic effects of *A. galli* and *A. columbae* include stunted growth and development in young birds, cessation of egg-laying in adults. Heavily infected birds loss weight, huddle and show diarrhoea, paleness, wasting and sometimes death. The parasites cause vitamin A deficiency resulting in low resistance to parasitic diseases (Ikeme, 1971a). The birds may also show emaciation, blood-tinged diarrhoea, listlessness, anaemia and gastric disturbances (Wehr, 1948). *Heterakis gallinarum*, though is apparently non-pathogenic, is the vector for *Histomonas meleagridis*, the highly pathogenic "blackhead" disease-causing flagellate (Soulsby, 1982).

5.3 *Experimental Infection of Columba livia domestica with Ascaridia galli*

The significant weight loss observed among experimentally infected birds agrees with the findings of Ikeme (1971c) and Ntekim (1983) whose studies were on chicken. Loss of weight in the infected group, especially after infection, may be due to loss of appetite (poor feeding) and the extraction or absorption of some of the host's nutrients such as amino acids and glucose by the parasite (Oniye *et al*., 2000a). *Ascaridia galli* infection causes weight loss in the host, which correlates with increasing worm burden (Reid and Carmon, 1957). Loss of weight is a common finding associated with pathogenicity of *A. galli*. Reid and Carmon (1957) had worked out the weight loss attributable to each worm at 1.39 g. The nutritional state of the chicken is also important since weight loss is greater with high dietary levels of protein (15.0%) than with low levels (12.5%) (Ikeme, 1971c).

The lack of significant differences ($P>0.05$) in the weekly changes in PCV, Hb level and total plasma protein values particularly in the infected group, tallies with the findings of Ikeme (1971a) and Dubinsky *et al*. (1974). This is probably an indication that infection with *A. galli* has little or no effect on these parameters.

The clinical signs observed in this study, have been reported by Ikeme (1971a); Soulsby (1982); Reid and Carmon (1958). Ntekim (1983) however, observed delay in the commencement of egg-laying and laying inefficiency in some infected chickens.

The low number of worms (87) recovered from the infected birds agrees with the observation of Roberts (1937), who noted that despite large number of eggs (up to 1,000 eggs per bird) fed to the birds, only a few worms were recovered from infected birds, most of which were very small in size. Sadun (1948) fed 1,250 to 8,000 eggs to 3 chickens and only one worm each was recovered from two of the chickens. Similarly, of the 338 chickens infected with 300 eggs each, by Reid and Carmon (1957), 58 (17.2%) harboured no worms and majority had less than 10 worms. In the repeated daily dosing of chickens, Ikeme (1971b) observed that out of 60 chickens fed, 10 eggs per day for 6 weeks, adult worms did not appear until as late as the tenth week, yet only 9 (15.0%) of the birds contained a total of 20 adult worms.

Haemorrhagic lesions observed in the lungs and liver of experimentally infected birds may be linked to the migration of the larvae during the tissue phase of the life cycle (Wehr and Shalkop, 1963). It has been reported that adult worms when present in large numbers, migrated up and down the intestinal lumen and the adults also aggregate in the lower half of the intestine where they cause intestinal obstruction and death of the infected pigeons (Ikeme, 1971a).

CHAPTER 6 SUMMARY CONCLUSIONS AND RECOMMENDATIONS

6.1 **Summary**

- The ectoparasites of the Columbids in Zaria comprised of the insects (*Menopon gallinae*, *Columbicola columbae*, *Goniodes* sp. and *Pseudolynchia canariensis*) and the arachnids (*Argas persicus* and *Dermanyssus gallinae*).
- *Menopon gallinae* and *C. columbae* were found on all the six Columbid speceis examined, *P. canariensis* was observed on five of the Columbids with the exception of Black-billed Wood Dove, *Goniodes* sp. and *D. gallinae* were found on Domestic Pigeon and Laughing Dove and *A. persicus* was recovered from Laughing Dove and Black-billed Wood Dove only.
- The ectoparasites exhibited evidence of site specificity and an over-dispersed distribution, 239 (32.5%) birds harboured between 1-5 parasites and only three (0.4%) birds harboured between 51-55 parasites.
- The percentage of mixed ectoparasite infestations was higher than that of single infestations in Domestic Pigeon, Mourning Dove, Speckled Pigeon and Vinaceous Dove but the reverse was the case in Laughing Dove and Black-billed Wood Dove.
- There was no significant difference between ectoparasite infestation of male and female Columbids ($P>0.05$).
- Ectoparasite infestations showed no significant effects on body weights and PCV values of infested Columbids.
- Ectoparasites were recovered on Domestic Pigeon and Laughing Dove in all the months of the year and there was association between infestation and the wet season.
- Some of the ectoparasites found on the Columbids, *M. gallinae, P. canariensis, A. persicus and D. gallinae* are vectors of some pathogens.

- The helminths of the gastrointestinal tract of Columbids in Zaria comprised of cestodes *Raillietina tetragona*, *Raillietina echinobothrida, Raillietina cesticillus*, *Raillietina magninumida*, *Amoebotaenia cuneata*, *Hymenolepis carioca*, *Hymenolepis cantaniana* and nematodes *Ascaridia columbae, Ascaridia galli* and *Heterakis gallinarum*.
- *Raillietina cesticillus* occurred in all the six Columbid species examined, *R. tetragona* and *A. cuneata* were found in all the Columbids with the exception of the Vinaceous Dove, *H. carioca* was observed in all the Columbids except in Black-billed Wood Dove, *H. cantaniana* was recovered in four of the Columbids with the exception of Speckled Pigeon and Black-billed Wood Dove, *R. echinobothrida* was observed in Domestic Pigeon, Laughing Dove, and Black-billed Wood Dove, *R. magninumida* occurred in Laughing Dove, Mourning Dove and Black-billed Wood Dove, *A. galli* and *H. gallinarum* was identified in Domestic Pigeon and Laughing Dove and *A. columbae* was found only in Domestic Pigeon.
- All the helminths were found in the small intestine, with the exception of *H. gallinarum*, which was recovered from the caeca.
- All the helminths showed an over-dispersed distribution, 253 (34.4%) birds harboured between 1-5 parasites and only one bird (0.1%) harboured between 61-65 parasites.
- The percentage of single helminth infections was higher than that of mixed helminth infections for all the Columbid species examined and there was no significant difference between helminth infections of male and female birds.
- Helminth infections showed no significant effects on body weight and PCV of infected Columbids.

- Helminths were recovered from Domestic Pigeon in all the months of the year with the exception of February, and throughout the year in Laughing Dove, and there was association betweenhelminth infection and the rainy season.
- New host records were observed for *Raillietina magninumida* in Laughing Dove, Mourning Dove and Black-billed Wood Dove, *Hymenolepis cantaniana* in Domestic Pigeon, Laughing Dove, Mourning Dove and Vinaceous Dove and *Heterakis gallinarum* in Domestic Pigeon and Laughing Dove.
- Clinical signs observed in *C. l. domestica* experimentally infected with *A. galli* were blood-tinged diarrhoea, loss of appetite, ruffled feathers, emaciation and weight loss. Histopathology showed the liver with coagulation necrosis of the hepatic cells, fatty degeneration, inflammatory cells and congested central vein. Haemorrhage and inflammatory cells were observed in the lungs. The heart showed necrosis of the myocardial cells and inflammatory cellular infiltration.

  The kidneys had tubular necrosis. The intestine exhibited necrosis of the intestinal villus and intestinal glands, and haemorrhagic enteritis.

6.2 **Conclusions**

- In conclusion, the ectoparasites of Columbids in Zaria comprised of lice, flies, ticks and mites, which have been implicated as causative agents of various diseases in other birds. These parasites show the Columbids as either the reservoir or transient hosts.
- The helminths of the Columbids were cestodes and nematodes. But the major causes of helminthoses could be associated with *Raillietina* spp. particularly *Raillietina tetragona* which was found throughout the year in most of the Columbids. Similarly, these helminths have been implicated in debilities and morbidity in domestic and wild birds.

- The helminths *Raillietina magninumida*, *Hymenolepis cantaniana* and *Heterakis gallinarum* have new host records, these show the Columbids as likely natural or experimental reservoir hosts of several helminths.
- Though sex did not confere specific advantage on parasite infestation or infection, the ecto and helminth parasites of the Columbids were more prevalent in the wet than in the dry season.
- The clinical and pathological manifestations in Dometic Pigeons experimentally infected with *A. galli* show that nematodes at low worm burden are detrimental to Columbids.

6.3 **Recommendations**

- A broad spectrum poultry acaricide as well as a broad spectrum poultry anthelminthic incorporated into either the feed and or water would reduce the prevalence of ecto and helminth parasites respectively of domestic pigeons, particularly during the wet season.
- For any effective control programme for ectoparasites and helminths in household domestic pigeons should be treated along side poultry since the pigeons may serve as reservoir or alternative hosts of poultry parasites.
- The control of ectoparasites and helminths of Domestic Pigeons may be more successful in the wet season than the dry season.
- Pigeons for consumption should be properly cooked or barbecued to avoid public health harzards.
- The establishment of the types of diseases transmitted by the ectoparasites found on Columbids is necessary.
- Further research is required to ascertain the intermediate hosts of the various helminths of pigeons.

- The experiment on infection of *C. l. domestica* with *Ascaridia galli* using squabs may give alternate clinical and pathological information.
- Molecular characterization of the *Goniodes* sp. Found in this study would shed more light on the taxonomy of the species.

REFERENCES

Abdu, P. A., Sa'idu, L. and George, B. D. J. (2002). Diseases of local poultry in Nigeria. *Discovery and Innovation*, 14 (1/2): 107-118.

Abdullahi, S.U., Abdu, P. A., Ibrahim, M. A., George, J. B. D., Sa'idu, L., Adekeye, J. O. and Kazeem, H. M. (1992). Incidence of diseases of poultry caused by non-viral infection agents in Zaria, Nigeria. *Book of proceedings of world poultry congress*, Amsterdam,The Netherlands, 20-24 September 1992, 159 pp.

Adam, K. M. G., Paul, J. and Zaman, U. (1971). *Medical and Veterinary Protozoology*. An illustrated guide, Churchill Livingstone, Edinburg and London, pp. 88-717.

Adang, K. L. (1999). Some aspects of the biology of four columbid species in Zaria, Nigeria. Unpublished M. Sc.Thesis. Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria.

Ademola, I. O. and Fagbohun, O. A. (2005). Helminth parasites of domestic pigeons (*Columba livia*) in Ibadan, Nigeria. *Bulletin of Animal Health and Production in Africa*, 53 (2): 147-148.

Agbede, R. I. S. (1981). A survey of ectoparasites and ectoparasitic conditions of animals in Zaria, Nigeria. *Journal of Animal Production and Research*, 1 (2): 179-180.

Ajayi, S. S. (1975). *Domestication of the African Giant Rat*. University of Ibadan, University Press, Ibadan, pp. 210.

Anderson, R. M. (1974). Mathematical models of host-helminth parasite interactions. *In*: Usher, M. B. and Williamson, M. H. (Eds), *Ecological Stability*, Chapman and Hall, London, pp. 43-70.

Angus, M. D. (1978). *Veterinary Helminthology*. 2nd Edition William Heinemann Medical Book Limited London, pp. 1-523.

Arends, J. J., Robertsoon, S. H. and Payene, C. S. (1984). Impact of Northern fowl mite on broiler breeder flocks in North Carolina. *Poultry Science*, 63: 1457-1461.

Arnall, L. and Keymer, I. F. (1975). *Bird Diseases*. *Neptune*, 54 (4): 102-109.

Atsineka, O. J. and Banke, R. O. K. (2006). Gastro-intestinal helminth parasites of domestic pigeons (*Columba domestica*) in Makurdi Metropolis, Benue State, Nigeria. In: *Book of Abstracts of the 3rd Annual Conference, Zoological Society of Nigeria*, 17 pp.

Audu, P. A., Oniye, S. J. and Okechukwu, P. U. (2004). Helminth parasites of domesticated pigeons (*Columba livia domestica*) in Zaria. *Nigerian Journal of Pest Diseases and Vector Management,* 5: 356-360.

Baker, E. W., G. W. and Fuller, H. S. (1956). *A Manual of Parasitic Mites of Medical and Economic Importance*. National Pest Control Association, New York, pp. 236-867.

Barrows, P. L., Barnes, J. H. and Hayes, F. A. (1977). Studies of endoparasites of mourning dove (*Zenaida macroura*) in the south east United States. *Journal of Wildlife Diseases*, 13 (1): 24-28.

Barus, V. (1966). Parasitic nematodes of birds in Czecholosvakia. *Falia Parasitology*, 3 (1): 7-27.

Bean, D. L., Rojas- Flores, E., Foster, G. W., Kinsella, J. M. and Forrester, D. J. (2005). Parasitic helminths of Eurasian collared-doves (*S. decaocto*) from Florida. *Journal of Parasitology*, 91 (1): 184-187.

Benbrook, E. A. (1965). External parasites of poultry. *In*: H. E. Biester and L. H. Schwarte (Eds), *Diseases of Poultry*. 5th Edition, Iowa State University Press, USA, pp. 925-964.

Bolton , B. (1973). *Bulletin British museum of Natural history* (ent) 27 (6): 317. *In*: Dede, P. M. and Richards, W. S. (1998). Prevalence of helmiathiasis in wild and domestic pigeons from the north eastern zone. *Bulletin of Animal Health and Production in Africa*, 46: 193-195.

Booth, T., Clayton, D. H. and Block, B. A. (1993). Experimental demonstration of the energetic cost of parasitism in free ranging hosts. *Proceedings Royal Society London*, 253:125-129.

Boyd, E. M. (1951). The external parasites of birds: a review. Wilson Bulletin, *Orbelin,* 63 (4): 363-369.

Bush, S. E. and Clayton, D. H. (2006). The role of body size in host specificity, reciprocal transfer experiments with feather lice. *Evolution International Journal of Organic Evolution*, 60 (10): 2158-2167.

Calentine, R. L. and Fredrickson, L. H. (1965). Periodicity of caryohy uaeid cestodes in the white sucker catostomus commersoni. *Iowa State Journal of Science*, 39: 243-250.

Cheesbrough, M. (1990). *Medical Laboratory Manual for Tropical Countries*. 2nd Edition, University Press Cambridge, 203 pp.

Cheng, T. (1973). *General Parasitology*. Academic press, New York, San-Francisco and London, pp. 434-936.

Clay, T. (1957). The Mallophagha of birds. *First Symposium Host Specificity Among Parasites of Vertebrates*, University of Neuchatel, Switzerland, 120 pp.

Clayton, D. H. and Cotgreave, P. (1994). Relationship of bill morphology to grooming behaviour in birds. *Animal Behaviour*, 47: 195-201.

Coles, E. H. (1986). *Veterinary Clinical Pathology*. 4th Edition. W. B. Saunders Company, London, pp. 145-769.

Conti, J. A. and Forrester, D. J. (1981). Inter relationship of parasites of white-winged dove and mourning doves in Florida. *Journal of Wildlife Diseases*, 17 (4): 529-536.

Crompton, D. W. T. (1973). The sites occupied by some parasitic helminthes in the alimentary tract of vertebrates. Biological Review. *Journal of Cambridge Philosophical Society*, 48:17-83.

Davis, J. W., Anderson, R. C., Karstad, L. and Trainer, D. O. (1971). *Infectious and Parasitic Diseases of Wild birds*. Iowa State University Press, USA, 145 pp.

Dede, P. M. and Richards, W. S. (1998). Prevalence of helminthiasis in wild and domestic pigeons from North-east zone of Nigeria. *Bulletin of Animal Health and Production in Africa*, 46: 193-195.

De Vaney, J. A. (1976). Effects of the chicken body louse *Menacanthus stramineus*, on caged layers. *Poultry Science*, 55: 430-435.

De Vaney, J. A. (1979). Effects of the Northern fowl mite, *Ornithonyssus sylvarium* on fertility and hatchability in Leghorn hens. *Poultry Science*, 57 (5): 1189-1191.

De Vaney, J. A., Elissalde, M. H., Steel, E. G., Hogan, B. F. and Del var Peterson, H. (1977). Effects of Northern fowl mite, *Ornithonyssis sylvarium* on White Leghorn roosters. *Poultry Science*, 56 (5): 1585-1590.

Dovc, A., Zorman-Rojs, O., Verges, R. A., Bole, H.V., Krapez, U. and Dobeic, M. (2004). Health status of free living pigeons (*Columba livia domestica*) in the city of Ljubljana, Slovenia. *Acta Veterinary Hungary*, 52 (2): 219-226.

Dubinnsky, P., Lestan, P. and Rybos, M. (1974). Effects of invasion of *Ascaridia galli* on the components of the host's blood serum. *Biologia Brastslava*, 29 (3): 229-236.

Elgood, J. H. (1960). *Birds of West African Town and Garden*. Longman, London, pp. 7-89.

Elgood, J. H. (1977). Forest Birds of Nigeria. *Ibis*, 119: 462-480.

Elgood, J. H., Heigham, J. B., Amberley, M. M., Anne, M. N., Sharland, R. E., and Skinner, N. J. (1994). *The Birds of Nigeria*. Checklist No. 4. British Ornithologists' Union.

Emerson, K. C. (1956). Mallophaga (chewing lice) occurring on the domestic chicken. *Journal of Kansas Entomological Society*, 29: 63-79.

Ezealor, A. U. (2005). Personal communication.

Fabiyi, J. P. (1972a). Studies on parasites of the grey breasted helmet guinea fowl (*Numidia meleagridis galeata pallas*) of the Vom area of Benue-Plateau State, Nigeria. *Bulletin of Epizootic Diseases of Africa*, 20 (3): 235-238.

Fabiyi, J. P. (1972b). Incidence of the helminth parasites of the domestic fowl in Vom area of Benue-Plateau State, Nigeria. *Bulletin of Epizootic Diseases of Africa*, 20 (3): 229-234.

Fabiyi, J. P. (1980). Survey of lice infecting domestic fowls on the Jos Plateau Northern Nigeria. *Bulletin of Animal Health and Production in Africa*, 28 (3): 215-219.

Fabiyi, J. P. (1988). Lice in infestations on doestic chickens in Nigeria. *Bulletin of Animal Health and Production in Africa,* 36 (4): 390-394.

Fairbairn, D. (1970). Physiological hatching of *Ascaris lumbricoides* eggs. *In*: Mclnnis, A. I. and Vogue, M. (Eds), *Experiments and Techniques in Parasitoolgy*. 1st Edition, Freeman , San Francisco, pp. 34-637.

Fatihu, M.Y. (1990). Prevalence and pathology of gastro intestinal helminths of poultry in Zaria, Nigeria. M. Sc. Thesis, Department of Veterinary Pathology and Microbiology, Ahmadu Bello University, Zaria Nigeria.

Farner, D. S. and King, J. R. (1973). *Avian Biology*. Academic Press London and New York, pp. 167-869.

Faust, E. L., Beaver, C. P. and Jung, C. R. (1962). *Animal Agents and Vectors of Human Diseases*, Lea and Feboger, Philadelphia, 461 pp.

Foronda, P., Vallandares, B., Rivera-medina, J. A., Figeruelo, E., Abreu, N.and Casanova, C. (2004). Parasite of *Columba livia* (Aves): Columbiformes) in Tenerife (Canary lsland) and their role in the conservation biology of the laurel pigeons. *Parasite*, 11(3): 311-316.

Frantova, D. (2000). Some parasitic nematodes (Nematoda) of birds (Aves) in the Czech Republic. *Acta Societatis Zoologicae Bohemicae*, 66 (1): 13-28.

Fry, C. H. (1965). The birds of Zaria. i. African migrants, ii. Palaeartic migrants, iii. Residents, Vagrants and check list (non-passerines) iv. Residents, Vagrants and checklist (Passerines). *Bulletin of the Nigerian Ornithological Society*, 2: 9-17, 35-44, 68-79 and 91-101.

Fry, C. H. (1966). *The Ecological Distribution of Birds in Northern Guinea Savanna.*_London Academic Press, London, pp. 73-778.

Gadzama, I. M. K., Olawuyi, N. A., Audu, P. A. and Tanko, D. (2005). Haemoparasites and intestinal helminths of the laughing dove (*Streptopelia senegalensis*) in Zaria, Nigeria. *Journal of Tropical Biosciences*, 5 (1): 133-135.

Galloway, H. J. (1972). *Farm Animal Health and Disease Control*. Longman, London, 80 pp.

Geets, A. and Ollevier, F. (1996). Endo parasitic helminths of white spotted rabbit fish (*Sigamus sutor valentiennes*, 1835) of the Kenyan coast: Distribution within the host population and micro habitat use. *Belgium Journal of Zoology*, 126: 21-36.

George, B. D. and Abdu, P.A. (1989). Pigeon fly, malaria and pox in domestic pigeon in Zaria, Nigeria. A case report. *Zariya Veterinarian*, 4 (1): 107-110.

George, J. B. D., Otobo, S., Ogunloye, J. and Adediminiyi, B. (1992). Louse and mites infestation in domestic animals in northern Nigeria. *Tropical Animal Health Production*, 24:121-124.

Glass, J.W., Fedynich, A. M., Small, M. F. and Benn, S. J. (2002). Helminth community structure in an expanding white-winged dove (*Zenaida asiatica asicitica*) population. *Journal of Wildlife Diseases,* 38:68-74.

Gless, E. E., and Raun, E. S. (1959). Effects of chicken body louse infestation on egg production. *Journal of Economic Entomology*, 52: 358-359.

Goethe, R. and Kunze, K. (1973). *Parasitic Zoonosis Clinical and Experimental Studies*. Academic Press, New York, pp. 369-682.

Goodwin, D. (1983). *Pigeons and Doves of the World*. 3rd Edition Ithaca, Cornell University Press and British Museum (Natural History), 363 pp.

Happold, D. C. D. (1987). *The Mammals of Nigeria*. Clarendon Press, Oxford, pp. 124-1025.

Harrison, L. (1961). The general and species of Mallophaga. *Parasitology*, 9 (1): 1-5.

Haruna, E. S., Musa, U., Lombin, L. H., Tah., P. B., Shamaki, D., Okewole, P. A. and Molokwu, J. U. (1997). Introduction of quail production in Nigeria. *Nigerian Veterinary Journal*, 18: 104-107.

Hensen, M. F., Olson, L.J. and Ackert, J. E. (1954). Improved techniques for culturing and administering Ascarid eggs to experimental chicks. *Experimental Parasitology*, 3:464-478.

Hofstad, M. S., Barnes, H. J. M., Calnek, B.W., Helmbodt, C. F., Reid, W. M., Yoder, H.W. Jr. (1984). *Diseases of Poultry*. 7th edition Iowa University Press, Ames, Iowa, pp. 824-825.

Hoogstraal, H. and Kohls, G. M. (1960). Observation on the subgenus. *Argas* (lxodoidiea. Argasidae: *Argas*) study of *A. reflexus* (Fabicius, 1794), the European bird argasid. *Annals of Entomological Society of America*, 53:611-618.

Hoogstraal, H., Wassef, H. Y., Easton, E. R. and Dixon, J. E.W. (1977). Observations on the subgenus *Argas* (Ixodoidea:Argasidae:*Argas*) 12. *Argas* (A) *africolumbae*: variation, bird hosts and distribution in Kenya, Tanzania and South-West Africa. *Journal of Medical Entomology*, 13 (4-5): 441-445.

Hore, P. N. (1970). Weather and climate of Zaria. *In*: *Zaria and its Regions*. Occasional

papers, Department of Geography, Ahmadu Bello University, Zaria, Nigeria, Number 4, pp. 8-12.

Howitt, B. F., Dodge, H. R., Bishop, L. K. and Gorrie, R. H. (1948). Virus of eastern equine encephalomyelitis isolated from chicken mites (*Dermanyssus gallinae*) and chicken lice (*Eomenacanthus stramineus*). *Proceedings Society of Experimental Biological Medicine*, 68: 622-625.

Ikeme, M. M. (1971a). Observations on the pathogenicity and pathology of *Ascaridia galli*. *Parasitology*, 63: 169-179.

Ikeme, M. M. (1971b). Effects of different levels of nutrition and continuing dosing of poultry with *Ascaridia galli* eggs on the subsequent development of parasite populations. *Parasitology*, 63: 233-250.

Ikeme, M. M. (1971c). Weight changes in chickens placed on different levels of nutrition and varying degrees of repeated dosage with *Ascaridia galli* eggs. *Parasitology*, 63: 257-260.

Jackoski, B. J. and Plank, J. D. (1969). Incidence of endoparasitism in a group of pigeons in Chicago area. *Avian Diseases*, 11 (3): 342-344.

Kemp, R .L. (1978). Haemoproteus *In*: Hofstad, M S., Barnes, H. J., M Calnek, B.W., Helmbodt, C. F., Reid, W. M., Yoder, H.W., Jr. (Eds), *Diseases of Poultry*. 7th Edition, Iowa State University Press, Ames, Iowa, pp. 824-825.

Kennedy, C. R. (1975a). *Ecological Aspects of Parasitology*. North-Holland, Amsterdam, pp. 173-489.

Kennedy, C. R. (1975b). *Ecological Animal Parasitology*. Black Well Scientific Publications, Oxford, pp. 51-533.

Keymer, I. F., Rose, J. H., Beesley, W. M. and Davies, S. F. M. (1962). A survey and review of parasitic diseases of the wild and game birds in Great Britain. *Veterinary Record*, 887-894.

Keymer I. F. (1969). Diseases of pigeons. *Veterinary Review*, Zoological Society of London, pp. 46-50.

Khoury, C., and Maroli, M. (2004). The pigeon tick *Argas reflexus* and hazard for human health. *Annals First Super Sanita*, 40 (4): 427-432.

Kiernans, J. E. (1975). A review of the phoretic relationship between Mallophaga (Phthiraptera: Insecta) and Hippoboscidae (Diptera: Insecta). *Journal of Medical Entomology*, 12: 71-76.

Kingstone, N. (1984). Trematodes. *In*: Hofstad, M. S., Barnes, J. H., Calnek, B.W., Reid, M.W. and Yoder Jr., H. W. (Eds), *Diseases of Poultry*. 8th Edition, Iowa State University Press, USA, pp. 668-690.

Kligerman, J. (1978). *A Fancy for Pigeons*. Hawthorn Books, New York, pp. 136.

Laison, R. (1960). The transmission of Lankesterella (Atoxoplasma) in birds by the mite *Dermanyssus gallinae. Journal of Protozoology*, 7: 321-322.

Lapage, G. (1956). *Monnig's Veterinary Helminthology and Entomology*, 4th Edition Baltimore, William and Wilkins Co, pp. 19-956.

Lapage, G. (1961). *Monning's Veterinary Helminthology and Entomology*. 5th Edition, Williams and Wilkins co. Baltimore, Maryland, 149 pp.

Lee, P L. M. and D. H. Clayton. (1995). Population biology of swift (*Apus apus*) ectoparasites in relation to host reproductive success. *Ecological Entomology*, 20: 43-50.

Levi, W. M. (1965). *Encyclopedia of Pigeon Breeds*. Levi Publications. Jersey City, New Jersey, 49 pp.

Levi, W. M. (1969). *The Pigeon.* (2nd Edition). Levi Publishing: Sumter South Carolina, pp. 48-79.

Loomis, E. C. (1984). External parasites. *In*: Hotstad, M. S., Calnek, B. W. and Yoder Jr., H. W. (Eds), *Diseases of Poultry*. 8th Edition, Iowa State University Press, USA, pp. 667-704.

Macrae, R. R. (1964). Pigeons as pets. Management, feeding, breeding and training of racing pigeons. *In: Proceedings of the British Veterinary Zoological Society*, 1961-1970: 65-75.

Malhotra, S. K. and Capoor, V. N. (1980). *Bioresearch* 4 (2): 55 *ln*: Dede, P. M. and Richards, W. S. (1998). Prevalence of helmiathiasis in wild and domestic pigeons from the Northeastern zone. *Bulletin for Animal Health and Production in Africa*, 46: 193-195.

Margolis, L., Esch, G.W., Holmes, J. C., Kuris, A.M. and Schad, G.A. (1982). The use of ecological terms in parasitology. (Report of an Ad Hoc Committee of the American Soceity of Parasitology). *Journal of Parasitology*, 68 (1): 131-133.

Marshall, A. G. (1982). *The Ecology of Ectoparasitic Insects*. Academic press, London, pp. 87-99.

Mettrick, D. F. and Podestra, R. B. (1974). Ecological and physiological aspects of helminth-host interaction in the mammalian gastrointestinal canal. *Advances in Parasitology*, 12: 183-249.

Michel, J. F. (1974). Arrested development of nematodes and some related phenomena. *Advances in Parasitology*. (Ed), Ben Dawes and New York. pp. 277-566.

Miller, W. J. and Wagner, F. H. (1955). Sexing mature Columbiformes by cloacal characters. *Auk*, 72:79.

Moller, A. P. (1993). Parasites as an environmental component of reproduction in birds. *Ardea*, 21(4): 17-24.

Murton, R. K. (1965). The feeding habits of the wood pigeon, *Columba palumbus*, Stock Dove, *C. Oenas* and Turtle Dove, *Streptopelia turtur*. *Ibis*, 106 (2): 74-98.

Mushi, F. Z., Binta, M. G., Chabo, R. G., Ndebele, R. and Panzirah, R. (2000). Parasites of domestic pigeons (*C. l. domestica*) in Sebele Garborone, Botswana. *Journal of South African Veterinary Association*, 71 (4): 249-250.

Nelson, B. C. and Murray, M. D. (1971). The distrbution of mallophaga on the domestic pigeon (*Columba livia*). *International Parasitology*, 1: 21-29.

Nfor, M. B. (1998). Studies on prevalence and pathology of parasites of guinea fowls (*Numida meleagris galeata*) in Zaria. Unpublished M. Sc. Thesis. Department of Veterinary Parasitology and Entomology, Ahmadu Bello University, Zaria, pp. 60-73.

Nosek, J., Hoogstraal, H., Labuda, M. and Cyprich, D. (1980). Bionomics and health importance of fowl tick, *Argas persicus* (Ixodoidea: Argasidae) *Zoologik Parasitenkd*, 63 (3): 209-212.

Ntekim, A. E. (1983). Experimental *Ascaridia galli* infection. Effects on egg-pullets. Unpublished M. Sc. Thesis, Department of Veterinary Parasitology and Entomology, Ahmadu Bello University, Zaria, Nigeria, pp. 65-81.

Olsen, O. W. and Braun, C. E. (1980). Helminth parasites of band–tailed pigeons in Colorado. *Journal of Wildlife Diseases*, 16 (1): 65-66.

Oniye, S. J., Audu, P. A., Adebote, D. A., Kwaghe, B. B., Ajanusi, O. J. and Nfor, M. B. (2000a). Survey of helminth parasites of Laughing Dove, *Streptopelia senegalensis* in Zaria, Nigeria. *African Journal of Natural Sciences*, 4: 65-66.

Oniye, S. J., Audu, P. A., Adebote, D. A.,.Oshiame, K. O. and Ajanusi, O. J. (2000b). A preliminary survey of helminths of *Francolinus bicalcaratus* bush fowl in Zaria, Nigeria. *African Journal of Natural Sciences*, 3: 88-89.

Orajaka, L. J. E. and Ezeokonkwo, R. C. (1977). *Haemoproteus columbae* infection in a flock of pigeons. *Nigerian Veterinary Journal*, 18: 187-189.

Owen, D. (1972). Common parasites of laboratory rodents and lagomorphs. *Medical Research Council Laboratory Station office*, London, 140 pp.

Petrak, M. L. (1969). *Diseases of Cage and Aviary Birds*. Lea and Febiger. Philadelphia pp. 394-906.

Petryszak, A., Rosciszewska, M., Bonczar, Z. and Pospiech, N. (2000). Analyses of the population structures of Mallophaga infesting urban pigeons. *Wiad Parazytology*, 46 (1): 75-85.

Philips, D. S. (1978). *Basic Statistics for Health Science Students*. Freeman, W. H.and Company, USA, pp.3 9-161.

Pilgrim, R. L. C. (1976). *Mallophaga on the Rock Pigeon* (*Columba Livia*) *in New Zealand, with key to their identification*. Department of Zoology, University of Canterbury, Private Bag, Christ Church, New Zealand, pp. 56-89.

Przystalski, A. (1988). Morphometry of alimentary canal in some passerine birds (Passeriformes). *Przegl Zoology*, 31: 139-157.

Read, C. P. (1959). The role of carbohydrates in the biology of cestodes. VIII: some conclusions and hypothesis. *Experimental Parasitology*, 8: 365-382.

Reid, W. M. (1956). Incidence and economic importance of poultry parasites under different ecological and goegraghical situation in Egypt. *Poultry Science*, 35: 926-933.

Reid, W. M. (1984). Cestodes. *In*: Hofstad, M. S., Barnes, J. H., Calnek, W., Reid, M.W. and Yoder Jr., H.W. (Eds), *Diseases of Poultry*. 8th Edition, lowa state University Press, USA, pp. 649-669.

Reid, W. M. and Carmon, J. L. (1957). Effects of numbers of *Ascaridia galli* in depressing weight gains in chicks. *Journal of Parasitology*, 43: 183- 186.

Roberts, F. H. S. (1937). Cited by Ikeme, M. M (1971). Weight changes in chicken placed on different levels of nutrition and varying degrees of repeated dosage with *Ascaridia galli* eggs. *Parasitology*, 63: 257-260.

Rosciszewska, M., Petryszak, A., Bonczar, Z. and Duda, M. (1996). Mallophaga of pigeons in Cracow. *Wiad Parazytology*, 42 (2): 235-242.

Rothschild, M. and Clay, T. (1952). *Fleas, Flukes and Cuckoos*. A study of Bird Parasites. New York, Philosophical Library, 304 pp.

Rowan, M. K. (1983). *The Doves, Parrots, Louries and Cuckoos of Southern Africa*, Academic Press, London, 429 pp.

Ruff, M. D. (1984). Nematodes and acanthocephalans. *In*: Hofstad, M. S., Barnes, H. J., Calnek, B.W., Reid, M.W. and Yoder Jr., H.W. (Eds), *Diseases of Poultry*. 8th Edition, lowa State University Press, USA, pp. 705-936.

Ruff, M. D. and Norton, R. A. (1997). Nematodes and acanthocephalans *In*: Calnek, B.W., Barnes, H. J., Beard, C.W., McDougald, L. R., Saif, Y. M. (Eds), *Diseases of Poultry,* lowa State University Press, USA, pp. 815-850.

Ruprah, N. S., Chaudri, S. S. and Gupta, S. K. (1986). General parasitology and platyhelminthes In: *Parasitological Manual*: 1 Haryana Agricultural University Hisar 125004, 97 pp.

Sadun, E. H. (1948). Resistance induced in chickens by infections with the nematode *Ascaridia galli. American Journal of Hygiene*, 47: 282-289.

Schillhorn Van Veen, T. J. and Mohammed, A. N. (1975). Louse and flea infestations on small ruminants in Zaria area. *Journal of Nigerian Veterinary Medical Association*, 4: 93.

Schock, R. C. and Cooper, R. (1978). Internal parasitism in captive birds. *Modern Veterinary Practice*, 59 (6): 439-440.

Serle, W., Morel, G. J. and Hartwig, W. (1992). *A Field Guide to the Birds of West Africa* Collins, Grafton Street, London. pp. 351.

Senlik, B., Gulegen, E. and Akyol, V. (2005). Effects of age, sex and season on the prevalence and intensity of helminth infections in domestic pigeons (*C. livia*) from Bursa Province, Turkey. *Journal of Parasitology*, 38 (4): 121-125.

Shotter, R. A. (1978). Aspects of the biology and parasitology of the Speckled Pigeon, *Columba guinea* L. from Ahmadu Bello University Campus, Zaria, North Central State, Nigeria. *Zoological Journal of Linneus Society*, 62:193-203.

Siuda, K., Hoogstraal, H., Clifford, C. M. and Wassaf, H.Y. (1979). Observations on the subgenus *Argas* (Ixodoidea:Argasidae:*Argus* 17. *Argas A. Polonius* sp. n. parasitizing domestic pigeons in Krakow, Poland. *Journal of Parasitology*, 65 (1): 170-181.

Symth, J. D. (1994). *Animal Parasitology*. Cambridge University Press, Cambridge, pp. 327-711.

Soulsby, E. J. L. (1982). *Helminths, Arthropods and Protozoa of Domesticated Animals*. 7th Edition, Bailliere Tindall, London, pp. 763-777.

Titchner, R. N. (1983). The use of permethrin to control an outbreak of hen fleas (*Ceratophyllus gallinae*). *Poultry Science*, 62: 608-611.

Wehr, E. E. (1948). A cropworm, *Capillaria contorta*, the cause of death in turkeys. *Proceedings of Helminthological Society of Washingston* D. C., 15: 80.

Wehr, E. E. and Shalkop, W. T. (1963). *Ascaridia columbae* infection in pigeons: a histopathologic study of liver lesions. *Avian Diseases*, 7: 206.

Welty, J. C. and Baptista, L. (1990). *The Life of Birds*. 4th Edition. Saunder, New York, pp. 53-67.

Whitney, L. F. (1968). *Keep Your Pigeons Flying*. Faber and Faber 24 Russell Square, London, 14: 183-196.

Yavornitskii, V. I. and Y. I. Kharambura (1982). Ectoparasitic infestation of the Rock Pigeon (*C. livia*) and the Collared turtle Dove, (*S. decaocto*) in the vicinity of Lvov, Ukrainian, *Vestn Zoologik,* 0 (3): 19-24.

Yusuf, M. and Associates (1981). *Ahmadu Bello University Master Plan Survey Report*, Volume 1. Dar Al Handash consultants, pp. 34-73.

Zaria, L.T., Sinha, P.K., Natiti, L.S. and Nawathe, D. R. (1996). Incidence of ectoparasites of domestic fowl in an arid zone of Nigeria. *Nigerian Journal of Animal Production,* 23 (1): 91-93.