

LICE IN MY LIFE

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by

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All men of whatever quality they may be,
who have done anything of excellence, or
which may properly resemble excellence,
ought, if they are persons of truth and
honesty, to describe their life with their
own hands.

Benvenuto Cellini
about 500 years ago

INTRODUCTION

For more than 40 years, working with lice (Mallophaga and Anoplura) has been one of the great pleasures of my life. My research has been interesting. It has been a pleasure to assist others understand the taxonomy, ecology and distribution of lice so that they can share my interest and then conduct research on their own. I have been able to provide good collections to The K. C. Emerson Entomology Museum at Oklahoma State University so that students there will not have to spend time in Washington, D. C. studying the groups. I have been able to improve the collections of the U. S. National Museum so that they are now rated among the best.

My enjoyment in doing the above has been attained without my ever being employed as an entomologist. Even though my academic major was medical entomology, with minors (strong training) in botany, parasitology, ornithology and ecology, I chose to work in those fields as avocations. I became an infantry officer in the U. S. Army, and later the top-level manager of research for the Secretary of the Army. In doing so, I was able to: travel extensively; meet scientists and visit museums in other countries; associate and learn from excellent scientists and engineers in other fields and countries; and obtain a salary which gave me freedom to conduct research I wanted to do, without the necessity of bureaucratic approval or supervision.

This freedom was attained by allocating no more than \$1,000.00 annually from my salary to support my avocations. Many people spend this much on bowling, golf, woodworking equipment, etc.; all of which I was willing to give up.

As the senior active American worker with lice, and one who helped start the modern era of Mallophaga taxonomic research, I decided now is the time to record what happened during the past 41 years. Every participant in history has a different view; what follows is an account of the events as I recall them. So, the reader must be tolerant of personal references.

WHY

Many people perhaps wonder why anyone would want to study lice.

I'm reminded of a statement by the head of a state department of health who said in World War II, "Everyone knows there's two kind of lice - adults and nymphs." If you ask most people they say, "There are head lice, body lice and crab lice." Then if you ask them about dogs, chickens, birds, deer, etc., then they usually reply "Oh yes, they also have lice because some got on me when I was cleaning a deer" or, "I had to bathe the dog to get rid of them before they got on the children and in the furniture." Those who served in World War II remember watching liberated peoples being dusted with DDT because they had lice. Actually several thousand species of lice have been described and named in scientific literature, and at least that many more have not been named or described; and the biology of only a few species is known.

When I was an undergraduate student in medical entomology in the 1930's, fortunately my professor was Dr. Lloyd E. Rozeboom. He had just returned to the U. S. from three years of research and study as a member of the staff of Gorgas Memorial Laboratory in Panama. His speciality was mosquitoes and the diseases they transmitted, but he was also aware of the other insects which were vectors or served as reservoirs of diseases. This stimulated his students to collect all insects which might be of medical or veterinary importance. He was a bachelor at the time, so we spent a lot of time collecting in the field. In

addition, he was a superb teacher and scientist. As our collection efforts accumulated specimens, Gaines Eddy started working on the identification of the fleas and ticks, and I started working on the biting midges (Ceratopogonids and Simuliids) and the lice.

I could find no one on the university staff who could help me identify the lice. So, I accepted the challenge and stepped into the dark; not knowing whether or not I could succeed. The mountain was there, so I had to climb it.

What follows is an account of part of what I learned, whom I met along the way, and some of the tangible results. Since it won't be mentioned in the following account, let me state now that the discipline and scientific training learned in the pursuit of this research helped me in everything else I undertook as an adult. I recommend such a project as an avocation for anyone who is curious about scientific or technical matters. In today's environment I would urge that it be in the biological sciences, rather than in the engineering or physical sciences because the training or education (even self-taught) in the biological sciences better prepares one to understand engineering or physical sciences and technology than vice versa. For example the operations research techniques which came into use in engineering and many other fields in the 1960's are essentially those biologists developed a generation earlier. Understanding organisms is never complete, and can never be completely reduced to a formula or formulae as in the physical and engineering sciences. Study and research can

give you some potential boundaries of a problem, some of the limitations and an appreciation of some of the possible solutions.

Perhaps this is why bird-watching is becoming more popular, and more people are becoming concerned about ecology.

EARLY HISTORY OF RESEARCH ON LICE

There are three known records concerning lice, written before the birth of Christ, and fifteen before the seventeenth century. In the seventeenth century were thirteen, and F. Redi published more on lice in 1668 than all of his predecessors combined. Twelve papers were published on lice in the eighteenth century before Linnaeus published his *Systema Naturae*, Editio X, in 1758. As with other organisms, the classification of lice (Mallophaga and Anoplura) used today had its origin in 1758. C. von Linnaeus described 27 species of Mallophaga (Chewing Lice) and five species of Anoplura (Sucking Lice). More names were mentioned by Linnaeus, but only 32 names were accompanied with descriptions adequate to meet the International Rules of Nomenclature; adopted in the early 1900's.

After Linnaeus, E. L. Geoffroy, E. Pontoppidan, J. A. Scopoli, J. C. Fabricius, F. von Schrank, O. Miller, O. Fabricius, C. de Geer, F. Fourcroy, and I. von Olfers described species between 1758 and 1818 which are still valid. However as Clay and Hopkins stated in 1950 "Nitzsch is rightly considered the pioneer of our systematic knowledge of the group, because he was the first after Redi to make a special study of the insects parasitic on mammals and birds. Unfortunately Nitzsch paid no heed to the Rules of Nomenclature, and in his paper published in 1818 (the only one published by himself in which he gives specific names) he considered it necessary to rename, with

only one or two exceptions, all the species mentioned by him which had already been named by previous authors, quite regardless of whether the names formerly given them were valid or not."

Clay and Hopkins published a four-part "The Early Literature on Mallophaga" between 1940 and 1960, which addresses all species named by Linnaeus and others prior to Nitzsch.

The first paper on species collected in North America was published in 1836 by J. G. Children.

The next worker of consequence was H. C. C. Burmeister who published on Mallophaga in 1838, and Anoplura in 1839. The next significant paper was that of H. Denny, published in 1842. In 1946, I was able to obtain a copy of Denny's book, in good condition, for ten dollars.

Papers published in this first period hampered research on lice until the mid-1900's because often the descriptions and illustrations (if used) were so vague that in the absence of types (which were lost or destroyed) names were not fixed in a manner that was acceptable to all workers.

The second period began in the 1860's and lasted until the beginning of World War I. Workers of note in this period were: C. G. A. Giebel (who also included in some of his papers descriptions by Nitzsch), F. Rudow (poorest of the lot), A. S. Packard (the first American to publish descriptions of species which are still valid), E. Piaget, O. Taschenberg, Herbert Osborn, L. G. Neumann, Vernon L.

Kellogg (and his co-authors, all of whom were his students), M. A. Carriker, S. A. Le Souëf, R. Bullen, G. Enderlein, E. P. Durrant, H. Fahrenholz, E. Mjöberg, J. Waterston, B. F. Cummings, L. Harrison and G. F. Ferris. During this period descriptions and illustrations were much better. Most of the types (or type material) still exists so they can be studied with better equipment than was available when the original descriptions were published.

Vernon L. Kellogg deserves special mention because he and his students were very productive from 1896 to the 1920's. Herbert Osborn and M. A. Carriker were two other Americans who published major works during this period.

Lancelot Harrison, an Australian, published in 1916 a list of the genera and species of Mallophaga which was incomplete, but useful until 1952. After he returned to Australia after 1918, he did only one worthwhile taxonomic paper on lice.

The third period extended from World War I to the late 1930's. During this period a few new workers entered the field and published new descriptions, and a few new genera were erected for the more diverse species groups. Notable in this group were S. Uchida, G. H. A. Bedford, G. F. Ferris, H. E. Ewing, F. L. Werneck, S. von Keler, G. B. Thompson and J. H. Paine. Others who made contributions were H. S. Peters, M. Sugimoto, M. A. H. Qadri, S. B. Pessoa, L. R. Guimaraes and R. O. Malcomson.

During this period male genitalia became significant in the

separation of species, and there were several good studies on internal and external anatomy. As more material became available, new genera were established; however, significant advances were to occur later when extensive collections made during this period were studied. In addition to the above, Cummings, Waterston, and Fahrenholz from the earlier period were also productive in this period. Ferris made several significant contributions. He introduced the split drawing for specimens - the entire dorsal view on one side, the entire ventral view on the other side. The plate had split drawing of the male, split drawing of the female and the male genitalia; plus any feature of special interest. This plate became his style, and is now common in lice descriptions. His "Contributions toward a monograph of the Sucking Lice, Volumes I-VIII" begun in 1919 and completed in 1935 established a new standard for descriptions; which is still used today. No major revision of Anoplura was necessary until the 1960's.

During this period, there were significant advances in the taxonomy of Mallophaga found on mammals. Three scientists were responsible.

G. A. H. Bedford, a South African scientist, in 1927 began publishing taxonomic papers on Mallophaga found in Africa. His papers continued through 1939 and were especially useful for the species found south of the Sahara. His papers were better than those of H. E. Ewing published during the same period on North American species.

F. L. Werneck, on the staff of Instituto Oswaldo Cruz in Brazil, in 1931 began his studies on Mallophaga found on South American mammals.

He published a comprehensive paper on the subject in 1936. Even though he used an old generic classification, his paper was useful because the illustrations, descriptions and host records were good.

Later he published a two-volume treatment of all known mammal Mallophaga. The first volume was published in 1948, and the second volume in 1950. In these two volumes he used the generic classification which is still in use today. After these two papers were published, he published a few odd descriptions of new mammal Mallophaga; but devoted most of his effort to Anoplura. Unfortunately he died before his accomplishments on Anoplura equaled those of his work on Mallophaga.

This period had several types of workers; those schooled earlier who did not change standards, older workers who continued to improve, and younger workers who were to contribute significantly to changes in Mallophaga Taxonomy.

THE CHANGES BEGIN

The period of transition in lice taxonomic research started in the late 1930's and ended in 1952.

When I started working with lice in the late 1930's, Ferris had completed his comprehensive study of the Anoplura and with his papers it was possible to identify all known species, and readily determine which specimens represented new species. There was no comparable reference which could be used to identify the Mallophaga. In fact, there wasn't a single decent generic key, or key to the species of a single genus. Ferris started working on Mallophaga in 1915, as a student under Vernon L. Kellogg at Stanford University; so when I encountered problems with identification of Mallophaga I sought help from Ferris and H. E. Ewing at the U.S.N.M. Ewing was no help. Ferris helped me as much as he could, but he had not worked with Mallophaga for more than ten years and his interest had turned to the scale insects. He loaned specimens and offered advice freely, both of which were welcomed and helpful.

By the fall of 1939 I had a good collection of local Anoplura and Mallophaga, and had traded for a fair number of foreign species. Since there was no good reference on the classification of Mallophaga, it took many hours before I felt confident with a classification that I had developed. After my first papers were sent to

scientific journals, I found that Theresa Clay in England, Stefan von Keler in Germany, F. L. Werneck in Brazil, G. B. Thompson in England and M. A. Carriker in the U. S. had also begun working on Mallophaga, and that we were all essentially in agreement on a new classification. G. H. E. Hopkins in Uganda, and W. Eichler in Germany had also started but I did not become aware of their work until after World War II.

I withdrew from graduate school at Oklahoma State University and began active duty with the U. S. Army, as an infantry officer, on March 3, 1940 at Fort Sam Houston, Texas. I took my library and slides with me and continued to collect specimens during 1940. Enroute to the Philippines in January 1941, I was able to spend some time with Gordon Ferris and study the Kellogg Collection at Stanford University. At that time the only student he had studying lice was Oliver B. Cope, who later joined the Fish and Wildlife Service. I found Ferris to be everything I had hoped he would be: brilliant, patient, helpful, and well grounded in many fields of science. We developed a friendship which lasted until his death, and as long as he lived he helped me. After World War II, he was the first to encourage me to pick up the pieces and start again.

While in Hawaii, I managed to spend two days at the Bishop Museum, where Elwood Zimmerman provided the Mallophaga in the museum for study.

In the Philippines I obtained a good collection Mallophaga collected by ornithologists on the staff of the Bureau of Science.

Before these specimens could be mounted and studied, I was captured on Bataan and remained a prisoner of war until September 1945. My experiences as a prisoner of war are recorded in "Guest of the Emperor", published in 1977. My collection and library were among the possessions lost in the Philippines.

During the winter of 1945-6 I visited the American Museum of Natural History and studied their Mallophaga Collection, with the help of Dr. C. H. Curran, a Dipterist. While in New York City, I visited many times with Mr. John D. Sherman, the best dealer in entomological books and reprints, and purchased copies of everything he had on Mallophaga and Anoplura. Thus my new library was better than the one lost earlier.

In the fall of 1946, I obtained an assignment to Oklahoma State University to help activate the R.O.T.C. unit. I did this so I could continue my graduate studies at the same time, even though it was against Army Regulations at the time. I immediately began collecting and studying Mallophaga and Anoplura again. Correspondence was exchanged on a regular basis with Clay, Carriker, Werneck, Hopkins, Ferris and Keler; all but Keler provided me with reprints of all their papers published in my absence.

To insure that I didn't falter at that time, Ferris sent me the Kellogg Collection of Mallophaga to study. He asked that I preserve the original label, if possible" when remounting specimens. The original mounts were unsatisfactory for detailed study.

He also agreed I could keep representative duplicates; however, all specimens which should be designated Lectotype would be returned. Fortunately the specimens Kellogg described and illustrated had "fig'd" written on the slide labels. While remounting some of the specimens I found the chemicals being used were not pure, so some of the specimens were not much better after remounting.

When I wrote Harold S. Peters for reprints of his papers, he sent them and asked if I would be interested in buying his Mallophaga Collection. After several exchanges of letters on the subject, we could not agree on what his collection was worth. I suspected at the time that he really wasn't anxious to part with it.

So, when Hopkins started preparing a modern checklist of the Mallophaga, I helped by giving opinions on the species described from North American hosts. Hopkins sent me a carbon copy of his first draft as he completed sections, so that we could discuss questionable assignments of hosts and synonyms. When "A Check list of the genera & species of Mallophaga" by Hopkins and Clay was finally published in 1952 it represented the majority opinion of the active mallophaga workers. I was fortunate to have a major part in development of that new classification. Only minor changes have been necessary since its publication.

While at Oklahoma State University my collection grew rapidly from these sources:

My own collecting in the field and from museum skins.

Mallophaga from Arizona birds provided by Alan

R. Phillips.

Mallophaga from Canada provided by G. J. Spencer.

Mallophaga and Anoplura solicited from students

in entomology, mammalogy, and ornithology in

several universities.

Ectoparasites collected by Army biologists con-

ducting ecological surveys.

Fish and game officials in several states.

Mallophaga from seashore birds collected in the

Galveston, Texas area by Russell Strandtman.

Exchange of specimens with Clay, Hopkins and

other workers.

In the spring of 1949, Frank M. Carpenter of Harvard University delivered the Sigma Xi Lecture at Oklahoma State University. Afterwards we had a long discussion and I offered to drive him to the train station in Perry the next day. During our discussion he mentioned that he had a PhD candidate, Robert L. Edwards, who wanted to do research on Mallophaga for a dissertation. Since Frank knew little about the taxonomy of Mallophaga, he asked if Bob could come study with me. I agreed and a few weeks later, Bob arrived. He had all the talents I hoped for in a student: good basic training in the biological sciences; field experience in mammalogy, ornithology, plant and animal ecology; could draw

well; and had a keen scientific mind. Within a week he made notes and illustrations necessary to continue his research after returning to Harvard. Unfortunately Bob did not stay with his research on lice. He hasn't lost his interest in them, but is currently director of a laboratory for commercial fisheries in Wood's Hole, Massachusetts. His talents are not being wasted because he is also very good in that field. Our present policies on commercial fishing off the northeastern coast resulted from his work, especially while serving as the American official observer aboard Russian fishing vessels.

Dr. William L. Jellison, Rocky Mountain Laboratory, Hamilton, Montana and Mr. C. F. W. Muesebeck, U.S.D.A., U. S. National Museum were both helpful during this period by loaning and exchanging specimens. A few years ago when Dr. Jellison retired, his collection of lice was transferred to the U. S. National Museum.

After World War II when Keler was having a difficult time in Berlin, I started providing him with CARE Packages so he could survive more easily and resume his research. He insisted in paying by providing photo copies of all his lice papers. When Hopkins retired in Uganda and moved to England, he was not permitted to take all his assets with him, so I sent him CARE packages until the food situation in England improved and he could get the remainder of his assets out of Uganda.

After a couple of years of correspondence with Dr. Harry D. Pratt, Communicable Disease Center, near Atlanta, Georgia, I visited him in the spring of 1950. During this visit I met Dr. Richard H. Foote, then a mosquito expert; Chester J. Stojanovich, a former student of Ferris who was working on Anoplura; and Harold S. Peter, then working on a Mourning Dove project in the southeastern states. Dr. Pratt was teaching courses in insects of medical importance for federal and state health workers. He had begun a slide collection of lice and fleas to assist in his teaching, and as a reference collection. I arranged to exchange duplicates. In 1978 his collection was transferred to the U. S. National Museum, and the specimens I had given him are now in the National Collections.

At lunch, Harold S. Peters brought up the subject of his Mallophaga Collection. He asked if I was still interested in buying it. I said that my collection had grown so that it was doubtful that he had any species I needed, hence it wasn't worth as much to me as it was a few years earlier. In the 1970's Harold finally sold his collection to the Florida State Museum. Since then I examined it, and am glad I didn't buy it; because it contained very little of value to me. However it was a good addition for the Florida State Museum.

In the summer of 1951 I was transferred to Germany to serve with the Allied Occupation Forces in Mainz (French Zone) for three years.

I took my collection and library with me and produced several scientific papers during my stay in Germany. Field collecting was limited to picking over road-kills and birds who died a natural death or were accidentally killed; however I collected off bird skins in one museum and hired a graduate student in ornithology to collect off bird skins in another museum. When I left German I had many Old-World species and good material from the former German Colonies (lost after World War I). Fortunately friends in the U. S. continued to send me specimens.

THE NEW ERA IN LICE TAXONOMY

In 1952, Hopkins and Clay published "A check list of the genera & species of Mallophaga". As mentioned earlier this was a historical milestone in Mallophaga Taxonomy. All known publications on Mallophaga, containing taxonomic information were reviewed and the species were placed in a modern classification. The result was that 201 genera and 2,657 species were considered valid. Included in the total number of species, subspecies were included; as they did not separate species and subspecies in the list. The species names rejected totaled 776. Publication of this important paper marked the beginning of the new era in lice taxonomy, as it served as the new base from which further research could be undertaken.

In the spring of 1953 I was able to visit Theresa Clay and study specimens in the British Museum. I was working on the genera *Menopon* and *Rallicola* at that time. Clay was also working on the genus *Rallicola*, so we coordinated our effort on the genus *Rallicola*; hence there was no duplication in the two papers. Thereafter we coordinated with each other on proposed studies. Since there was so much to be done, we each felt any duplication of studies would be detrimental.

At that time Theresa Clay had already erected 23 genera for diverse groups. These actions were long overdue and helped in

development of the Mallophaga classification in use today. In addition, her paper on *Lipeurus* and related genera and the one on *Goniodes* were superb. After my visit Theresa Clay continued publishing excellent reviews of Mallophaga genera and keys to other genera and families. Every paper Theresa Clay published was excellent and a real contribution to our knowledge of Mallophaga. In addition, she was a nice person. I'm sure that she was influenced by her uncle, R. Meinertzhagen, a noted ornithologist. In fact, prior to his death they made collecting trips together.

On that trip I was also able to visit Hopkins at the Tring Museum and meet Jordan and Smit, the old and the new flea specialists. I stayed in the home of "Harry" Hopkins and found not only was he a good host, but a great scientist with multi-discipline training and experiences. His philosophy and standards were almost identical to those of Gordon Ferris, so I felt at home in his presence. He gave me a package of African lice as a gift, upon my departure. The next week Queen Elizabeth II was crowned.

That summer one Saturday evening Wolddietrich Eichler called me to say he was at a local cafe and asked if I could come see him. I did and found him to be an easy man to talk with, even though our views on classification were poles apart. He wanted me to provide him copies of papers by American workers and specimens. I agreed to do so, if he would improve the quality of his

work. He didn't, so my cooperation dwindled over the years. His taxonomic work was the poorest of any modern worker, however his non-taxonomic work was much better. I suspect that he was required to be productive -- turn out papers -- to retain his position in East Germany, so he met or exceeded his assigned quota.

Unfortunately I was unable to visit Berlin and meet Keler, or to visit in Hamburg and meet Timmermann.

In the last year of my stay in Germany, I began study of the Mallophaga collected by Harry Hoogstraal and his colleagues on the Field Museum Zoological Expedition to the Philippines in 1946 and 47. This study was done jointly with Ronald A. Ward, a graduate student at the University of Chicago. After the first paper was prepared for publication, I decided not to continue with the remainder of the material. Apparently no attempt had been made to insure the birds were kept separate in the field until the lice could be picked off and placed in vials. After a few months, trying to match lice with host data, I gave up. Later Ron Ward and I published papers, based upon other specimens. Since the host provides the environment in which lice live, the name of the host is more important than the locality. Early literature, and until the early 1900's, field collections often contained poor host data which have taken years to correct. Anyone working with lice can appreciate the problem this causes

I returned to the United States in July 1954 and was able to spend a week in Washington, D. C. At that time I met Mr. Muesebeck, Mrs. Penelope Smallwood (the best slide preparator I know), Robert Traub and Phyllis T. Johnson; all of whom became associates later.

When I saw the lice collections in the U.S.N.M., I was appalled to see they were so small. I had expected them to be at least as large as mine. At that time I decided that something must be done, and the first item would be that after arrival in Kansas I would send duplicates from my collection.

Dr. Robert Traub was very active in field collecting for fleas and parasitic mites. So we discussed how he could help me. He told me Robert E. Elbel was collecting lice in Thailand, and suggested I get in touch with him.

After my arrival in Leavenworth, Kansas I established contact with Bob Elbel in Thailand, and he agreed to send me Mallophaga from Thailand. He sent the Anoplura to Phyllis Johnson. The Mallophaga were eventually split three ways: 1 part to Bob Elbel, 1 part to me, and the rest to the U.S.N.M. When Bob returned to the U. S., he made frequent trips from Lawrence, Kansas to Leavenworth to study lice. He then went to the University of Oklahoma where he continued field collecting, while working on his PhD. His dissertation on Mallophaga of Hornbills and subsequent papers on Mallophaga are excellent.

John S. Wiseman, Texas State Department of Health, decided to work on Mallophaga for his PhD at Texas A. & M. University. Before starting he spent some time with me at Leavenworth, Kansas studying the species likely to be encountered in Texas -- the subject of his dissertation. Jack Wiseman, upon his return, started sending me specimens from Texas; and his faculty advisor M. A. Price also sent specimens.

While at Leavenworth, Kansas I worked with Rollin H. Baker, a mammalogist (now at Michigan State University) and Harrison B. "Bud" Tordoff, an ornithologist (now at University of Minnesota), both then at Kansas University, to obtain lice from their collecting and any specimens obtained by their students. Rollin Baker had started his research on pocket gophers in Mexico. He collected plenty of lice, which resulted in the revision of the Mallophagan genus *Geomydoecus* which Roger Price and I published in 1971. These collections were made possible by funds provided by the U. S. Army.

The U. S. Army conducted ecological surveys of several posts, but the most lice collected were on Dugway Proving Ground in Utah (an area larger than the state of Rhode Island). Specimens from those surveys are in my collection and I provided specimens to the U.S.N.M.

One of the highlights of my stay in Leavenworth, Kansas was a visit by M. A. Carriker. After many years of correspondence and exchange of specimens I finally met him. Later after I moved to

Arlington, Virginia he made two more visits to our home. Carriker was a delightful visitor. Our sons and I enjoyed his stories of collecting in the jungles of Central and South America -- almost continuously from 1902. He was a prolific writer, describing more than 500 species of Mallophaga, so he deserves a key place in the history of Mallophaga Taxonomy. While a student at the University of Nebraska, he went on a field collecting trip to Costa Rica. He became fascinated by what he saw and stayed in the country to collect after the other students returned to Nebraska. He stayed in Central and northern South America, and married the daughter of an American who owned a coffee plantation. Carriker continued collecting birds because his main interest was ornithology, but he collected the lice off the birds taken; until he lost his own coffee plantation. He worked as an ornithologist at the Carnegie Museum and the Philadelphia Academy of Natural Sciences for short periods in the 1920's and the late 1930's. The pay at the Philadelphia Academy of Natural Sciences was not adequate to support his family, so he became a carpenter. He said he was helping build Fort Dix, New Jersey when one cold autumn afternoon Alex Wetmore (Secretary of the Smithsonian) stopped by to see him and determine if he (Carriker) could be hired to go on a collecting trip in Mexico. Carriker said "I threw my tools down and said I'm ready now."

After that, Carriker lived outside the United States and collected birds (and their lice), conducted research on birds and

Mallophaga and published scientific papers on both. One son became a marine biologist, one a painter, and one an eye surgeon. He had one daughter, but I don't remember whom she married.

We had many useful discussions on Mallophaga Taxonomy. In studying his specimens, one should remember a few points: (1) he thought the type series should be off only one bird, (2) he tended to think that lice were specific for subspecies of hosts. He found this to be true among the Tinamous and expected it in other orders of birds, (3) because of his isolation and old equipment, many of his illustrations are misleading -- the differences he drew often were caused by poor mounting, (4) he did not allow anyone to read his manuscripts prior to submission to an editor -- mistakes which should have been detected in the draft manuscript were not corrected, and (5) any author who relegated one of his species to a synonym didn't know Mallophaga and he usually treated them roughly in his next paper. I'm sure that many of the species described from single specimens, some of which even ended up in different genera, resulted from contamination on the skinning table. Alex Wetmore once asked me, after Carriker's death, "How many of Carriker's species would stand the test of time?" My reply was probably about 60%. Alex Wetmore's reply was, "That's pretty good." Those of us now in Mallophaga Taxonomy consider that percentage is below standard. However, in consideration of the diverse forms of Mallophaga

Carriker saw over a long period of time, and the fact that for most of that period, a proper taxonomy of Mallophaga was evolving; he did a remarkable job.

Carriker came to Leavenworth, Kansas not only to see me and discuss Mallophaga, but to solicit help in obtaining slides, coverslips, mounting media, slide boxes, and drawing paper. I agreed to keep him supplied with these items in exchange for duplicates. Dr Wetmore was providing him shotgun shells for the opportunity to have first choice to purchase bird skins he collected. Carriker made his living, at that time, by selling bird skins to museums. During his visit I expressed concern for the safe-keeping of his collection in Colombia and urged him to make provisions so that it could be transported to the U.S.N.M. when he no longer was active in research on the lice.

When he left Leavenworth, we drove him to Kansas City so he could catch a bus to Denver where his son, the surgeon, was serving in the U. S. Army. We also provided him a home-cooked chicken lunch in a shoebox for the trip. This was before "Kentucky Fried Chicken" was available commercially.

In May 1958 Gordon Ferris died. With his passing the United States lost a great scientist and I lost a good friend and mentor in the study of lice.

While I was at Leavenworth, Kansas all the specimens I collected were sent to Mr. Muesebeck and Dr. Phyllis T. Johnson and they had

Mrs. Smallwood prepare the slides. They did this in return for my identifying all Mallophaga sent to them for identification. This permitted Dr. Johnson to concentrate on her studies on fleas and the Anoplura. During this period, I started sending the U.S.N.M. specimens in my collection surplus to my needs, and shared some of my rare specimens.

My brother-in-law, who lived in Silver Spring, Maryland, was killed in an airplane crash in June 1958. When I came to Washington for his funeral, I spent an afternoon with Phyllis T. Johnson and Mr. Muesebeck in the U.S.N.M. At that time, Phyllis was hard at work on several papers on Anoplura.

In September 1958, I was transferred to Korea for a year's duty. Enroute I was able to find time to study collections at the University of California in Berkeley, and The California Academy of Science in San Francisco. Upon my arrival in Korea, I found Chet Fennell working in the Army Personnel Office, an excellent self-taught ornithologist, was collecting bird skins for the University of California at Berkeley. He agreed to provide me the lice found on birds he collected. Chet was a bachelor, and spent all his free time collecting birds. He continued to send me specimens after I returned to the United States. Unfortunately he died a few years later of a heart attack while working for the U. S. Army in Japan.

While in Korea many people told me about K. C. Kim, a young student who left just before I arrived, to study in the United States.

In fact some of the small mammal skins he prepared and left behind were given to me. These I sent to the Mammal Collection at Oklahoma State University. Years later, I met Kim in Washington, D. C. while he was a graduate student at the University of Minnesota, and we have been friends and co-workers in lice for several years.

THE PAST TWENTY YEARS

In October 1959 I moved to Arlington, Virginia and started an assignment in the Pentagon. At that time I expected to retire from the Army soon after March 1960. However, I found the Army assignment so interesting, retirement was postponed until October 31, 1966.

After I rented a house and got settled, I called on Mr. Muesebeck. He showed me the Anoplura, Mallophaga and Siphonaptera Collections of the U.S.N.M., and asked if I would work on them. I agreed, so Dr. William Anderson, U.S.D.A. found room for me and the collections in the Department of Agriculture South Building. So from about January 1959 until the present I have served as Curator of the Anoplura and Mallophaga Collections. I also served as Curator of the Siphonaptera Collection until the three collections were moved to the Natural History Building on Constitution in 1971. Dr. Robert Traub has served as Curator of the Siphonaptera Collection since 1971.

I began working Sundays on the Collections. I did nothing with the Siphonaptera, except to add incoming specimens into the collection. Dr. Phyllis T. Johnson had left the flea collection in good condition. It was contained in 7 1/2 shelves of a steel-shelf unit. I did no more with the collection until it was transferred to Dr. Traub.

During 1960 three lice specialists, M. A. Carriker, Robert L. Edward and Phyllis T. Johnson visited me; otherwise my spare time was spent working on the U.S.N.M. Collection, my own collection and

preparing a few scientific papers. I spent my free week-ends working on the U.S.N.M. collections in the South Agriculture Building and research for my papers at home.

Bob Edwards came by for dinner and we spent several hours discussing Mallophaga, status of his paper on the genus *Halipeurus* and a proposed review of the genus *Aquanirmus*.

Phyllis Johnson came by for dinner and brought me up-to-date on her Anoplura research, and her work at the Gorgas Memorial Laboratory in Panama.

M. A. Carriker arrived after Christmas. He wanted to discuss Mallophaga, replenish his stock of supplies, and watch the post-season football games. He was an avid football fan, and strong supporter of the University of Nebraska football team. He still remembered, in great detail, the time Nebraska beat Minnesota while he was in college. Mornings were spent discussing Mallophaga and the afternoons watching football on T.V. He informed me that provisions had been made for the U.S.N.M. to have his Mallophaga Collection upon his death.

Carriker brought with him a few slides and drawings of new species he intended to describe. The proposed new species were "unusual specimens." When we started discussing them I became concerned that most were represented by only one or two specimens, obviously with incorrect host data. Every "new species" he showed me would result in my showing him a good series of a named species with correct host data in my collection. By the time we worked

through his slides and drawings, he was embarrassed. The papers were never published. I decided that rather than endanger my friendship with him, to never again review his papers before publication.

In the spare moments when we were not discussing Mallophaga, watching football games, or talking about his field trips; he read magazine articles on the "Old West." He was an avid reader of tales of the "Old West" and took a supply of new magazines back to Columbia with him.

We took him with us when we attended a Christmas-New Years Party in College Park, Maryland. All in attendance, except us, were U.S.D.A. or University of Maryland professional personnel and their wives. Mr. Carriker was the "hit of the party."

After the Rose Bowl game, he was ready to return to Columbia. He had obtained shot gun shells from Dr. Alexander Wetmore, and I gave him slides, cover-slips, labels, slide boxes and drawing paper to last a couple of years.

In the early 1960's Dr. Roger D. Price, University of Minnesota, wrote me that he wanted to study Mallophaga if I would help by loaning specimens for him to study. I sent him the specimens he requested, and after reviewing the draft of his papers, I concluded Mallophaga Taxonomy had found a winner. His papers were the best I had seen, and much better than mine or Theresa Clay's. His illustrations were superb, and there were plenty of them; which was a welcomed change in Mallophaga Taxonomy. In ten years he published 60 journal articles on Mallophaga, and his reviews of the comb-bearing species are classics.

If all future publications on Mallophaga Taxonomy are as good as those done by Roger Price, taxonomy of the order will be in good condition ten years from now.

Roger Price is systematically reviewing the Menoponid genera world-wide, publishing short papers on some of the smaller Philopterid genera; and has almost completed a monumental task of reviewing the Mallophaga found on pocket gophers.

As mentioned earlier, Gordon Ferris, G. H. E. Hopkins and Stefan von Keler died during this period. These good workers left their marks and are missed.

In 1964 Adams, a student at Mississippi State University and a fellow officer with me in Korea, notified me that E. W. Stafford had died and his widow offered me his collection. I accepted the offer and went to Starksville to meet C. A. "Arlie" Wilson and determine Mrs. Stafford's desires. Arlie stated Mississippi State University would like to have a collection of identified species, from the Stafford Collection, for a reference. I agreed to provide it. After the collection arrived it took me about six months to assemble the specimens for Mississippi State University, identify all decent slides, segregate specimens he had on loan from the U.S.N.M. and return them in the collection. Next I located the types of species he had described and placed them in the U.S.N.M. Collection. After that I selected examples of each species for my collection; and put the remainder in the U.S.N.M. Collection. Stafford had very poor eyesight in his later years, so his labels can be identified

easily because he used a large fountain pen and the lettering is so large that often data are abbreviated. Also, when he mounted specimens, some were so poor or damaged they had to be discarded.

M. A. Carriker, another old-timer, died July 27, 1965. Fortunately he was sick only a short time. The summer before he died he and his wife visited Alex Wetmore, his children, and me in the U. S. Since his wife did not speak English, the trip was difficult for both of them. He and Felicia (his second wife) stopped for a couple of days in Washington, enroute to see his son in Wood's Hole, Massachusetts. They expected to spend a week in Wood's Hole; however after a couple of days I got a call from him stating they were back, and staying with the Wetmores. He said things moved too fast in Massachusetts, and since his wife did not speak or understand English they were returning to Colombia. I was able to spend several hours with him at the Wetmores. He seemed discouraged because his wife didn't feel more comfortable in the U. S. I promised to send any supplies he needed. He stated he had given the Smithsonian Press, for publication, a catalog of the Mallophaga species he had described; and if they had any trouble with it would I help them.

After Carriker's death representatives of the U.S.N.M. went to Colombia and brought his Mallophaga Collection to the U.S.N.M. While there they sorted papers and also brought back all pertaining to his ornithological and Mallophaga research. The notes on Ornithology are now in the Bird Division, U.S.N.M. In his desk were

found drawings and manuscripts for several papers. I sorted through these and those ready for publication were included with his catalog in "Carriker on Mallophaga" which I edited for publication by the Smithsonian Institution Press in 1967. In this publication, the location of holotypes of species he described are recorded. While working on the catalog, I contacted Dr. George H. Lowery, Ornithologist at Louisiana State University, and he agreed to give the Carriker Holotypes he had to the U.S.N.M. And, all Holotypes of species described by Carriker from my material are now in the U.S.N.M. Collection. Unfortunately a few Holotypes were not found in his home in Colombia, and those missing are listed in the catalog. Perhaps they will be found at some future date. In 60 years of taxonomic research on Mallophaga, Carriker described 6 families, 53 genera and subgenera and 866 species and subspecies in 82 publications. His record probably won't be matched.

During the Christmas Season of 1965, James E. Kierans and his wife Laura visited us so he could study Mallophaga, from New England Birds, the subject of his dissertation at the University of New Hampshire. We had several enjoyable days working with the collection and still work together. Jim is now the tick taxonomist at the Rocky Mountain Laboratory, U.S.P.H.S., Hamilton, Montana and unfortunately does not have time for Mallophaga. However he often sends me specimens, and I send him the ticks which are sent to me along with phaga.

Bob Elbel and his wife came by for a few days so he could brush skins in the U.S.N.M. for specimens needed to complete his dissertation.

During one of my trips to the University of California (Berkeley) I met Bernard C. Nelson, a Ph.D. candidate in Entomology, who wanted to study Mallophaga for his dissertation. Bernie finally decided to examine the genus *Ricinus* found on songbirds.

At about the same time, G. Rheinwald, a student of G. Timmermann in Hamburg, Germany, decided also to study the genus *Ricinus*, and asked to borrow my material. Agreement was finally reached that Bernie would revise the New World species and Rheinwald the Old World species. Both produced excellent papers, and much to my surprise they agreed on the species which are holartic; even though they didn't correspond during their research. Bernie is now with the State of California Health Department, and G. Rheinwald is doing ornithological research in Bonn. When I visited Rheinwald in the 1970's I was pleased to find him a pleasant, well-informed young scientist who will do well in any scientific endeavor he chooses. The same is true of Bernie, and fortunately he has time to occasionally publish a paper on Mallophaga.

When I was in Bonn, Heinrich F. Klockenhoff was sick so we didn't meet. He is another young scientist who has a bright future in Mallophaga Taxonomy. His series of papers on the *Myrsidea* of the Corvidae (crows, ravens, Jay, magpies, etc.) are splendid, and I

would expect the same quality in the future. Fortunately I was able to loan him material from my collection and from the U.S.N.M. collection for his studies.

In about 1960 Donald W. Tuff, who was teaching at Southwest Texas State University, wrote that he wanted to study the Mallophaga on North American Ciconiiformes (egrets, herons, bitterns, etc.) and would I help. Specimens were provided, and he produced a good dissertation for his Ph.D. at Texas A&M University. His findings were published in a series of journal papers. In 1978 his student, William W. Hill, did a comparable review of the Mallophaga on North American Pigeons and Doves.

Robert C. Dalgleish, a graduate student at Cornell University, wrote that he wanted to study the Mallophaga on Piciformes (woodpeckers, flickers, etc.). His Ph.D. dissertation addressed the genera *Brueelia* and *Penenirmus* found on these hosts. During the time he was doing his research, he made several trips to Washington. After graduation, he became Executive Director of The Edmund Niles Huyck Preserve near Rensselaerville, New York. He is well suited for that job because his interests in birds and mammals are as great as for the lice and fleas. He travels quite a bit and is able to obtain specimens from collectors in many localities. He is a good field and laboratory worker, and will continue to produce Mallophaga papers as his schedule permits. He keeps current on research being done and visits the U.S.N.M. frequently each year.

His collecting on Trinidad will produce at least one new genus and several new species.

Earlier I mentioned hearing about K. C. Kim in Korea in 1958. One day in the late 1960's, while visiting the mosquito researchers on Lamont Street, I met K. C. Kim. He was a Ph.D. candidate at the University of Minnesota studying Diptera, mites, and Anoplura. Because of my background and experience in the Orient, from that meeting on we became good friends. It has been a real pleasure to watch him develop into the best living specialist in Anoplura, a well-rounded scientist, and an American citizen. His wife and children feel as much at home in our house as theirs. The only problem with Kim is that he has twice as much energy as everyone else I know, hence you can't keep up with him. He is now on the faculty of Pennsylvania State University.

After B. K. Tandan received his Doctor's degree in England, he returned to India and joined the faculty of the University of Lucknow. He wrote me asking for funds to collect bird Mallophaga so he could continue his studies. I contacted Dick Foote and Bill Anderson in the U.S.D.A. to determine if P.L. 480 funds were available to support his research. They got approval for such a P.L. 480 grant; and it continued for several years. I finally met Tandan in London in 1970. At that time he had taken a leave of absence from the University to study at the British Museum (Natural History) under Dr. Clay. He was a delightful person, with a mixture of

manners -- Indian and English -- and scientific training. I went through London semi-annually on my trips to the Continent for several years, so I always stopped for at least a day to visit with Theresa Clay and B. K. Tandan. The papers he published, while in London, on *Myrsidea*, *Ardeicola*, and *Esthiopterum* are excellent. However, since his return to India he has been burdened by the position of Chairman of the Department of Zoology, which will probably leave little time for taxonomic studies. On my second visit to London, Tandan told me he had to take a job as doorman, at night for a theater, because his study grant was inadequate. He said \$100.00 additional would be adequate to sustain him; so I gave him that amount. Since returning to India, Tandan asked that I serve on Committees to review the dissertation of two of his students: Vijai Dhanda and A. C. Mishra, both of whom worked on Anoplura. If these two men are typical graduate students, then he is to be commended because each has published several excellent papers.

It was a sad day for us when Phyllis T. Johnson had to stop her research on Anoplura. Her work was excellent, and her papers were well written and illustrated. Presently she is working on diseases of the Blue Crab, in a laboratory on the Chesapeake Bay in Maryland. We all hope that sometime in the future she can resume her research on Anoplura. She was a gracious hostess when I visited her in Panama.

Herbert Ludwig, on the faculty of the University of Heidelberg, is a German copy of Kim. His work on Anoplura is good, but his

teaching and administrative loads are excessive; therefore his time for research on Anoplura is limited. He came to the U. S. twice: first for the Pan-American Health Organization Conference on Lice in 1972, and second for the International Congress of Entomology in 1976. His work on the genus *Pedicinus*, Anoplura found on Old World Monkeys, straightened out a mess that existed for too many years. He had a student, Christian F. Weisser, who wanted also to study Anoplura so Ludwig arranged for him to study Anoplura for his Master's Degree under Kim at Pennsylvania State University. Then Christian would return to Heidelberg and do his Ph.D. research on Anoplura under Ludwig. Christian is now on the staff of Heidelberg University. He should be one of the new crop of Anoplura Taxonomists with a brilliant career ahead. He has published several papers on Anoplura which are excellent, collected extensively in Africa, Afghanistan and Pakistan, and should continue to do good work.

When the Pan American Health Organization Conference on Lice was being planned, I asked that Zofia Wegner of Danzig, Poland, be invited because she was another person publishing good papers on Anoplura. Her standards were high and equal to the best anywhere; however she was not publishing many papers. She appreciated the opportunity to talk with Ludwig and the U. S. lice specialists and to see the U.S.N.M. collection of Anoplura. She visited in our home before returning to Poland. I expect her to be more productive in the future because of her association with others at the conference,

and the fact that she is now able to obtain specimens from me and others. Until she came to the conference her research was limited to European species.

During one of my early trips to Panama, I met Eustorgio Mendez who had started working at the Gorgas Memorial Laboratory, while still in college. A couple of years later he came to Washington to study birds under Alexander Wetmore, who at the time was in the process of writing a multi-volume series on the Birds of Panama. During that year we had many sessions on taxonomy of Mallophaga and Anoplura. After his return to Panama, he started developing a reference collection of vertebrates in the Gorgas Memorial Laboratory. At the same time, he collected and studied their ectoparasites. Today he is well-qualified in the taxonomy of the Siphonaptera, Anoplura and Mallophaga found on mammals of Panama and northern South American countries. His papers on those subjects are excellent. He has also filled a big gap in Panamanian science by publishing handbooks for the identification of local birds and mammals.

I have corresponded with John A. Ledger, on the staff of the South African Institute of Medical Research in Johannesburg since he started his research on Mallophaga and Anoplura. In March of this year (1979) he and his wife finally visited in Washington. His papers, mostly on African species, are excellent; and if his duties as Chairman of the Department of Entomology permit I'm sure his contributions will be great in years to come. John is another of the

new generation who are knowledgeable in many fields; and therefore have much to offer when they publish papers on Anoplura and Mallophaga.

Japan produced three serious students of lice taxonomy: S. Uchida who worked on Mallophaga from 1915 through 1949, and Manabu Sasa and Kiyotoshi Kaneko who are working on Anoplura.

For a number of years, M. D. Murray has been doing excellent research on the biology of Mallophaga and Anoplura of economic importance. Even though he has published no taxonomic papers on either order, he must be considered "one of us". His talk at the International Congress of Entomology, held in Washington, D. C. in 1976, left no doubt as to competence. Bernie Nelson spent one year in Australia working with him, and the two are probably the best qualified to establish and maintain laboratory colonies of Mallophaga.

Ricardo L. Palma, of New Zealand, is new in the field of Taxonomy of Mallophaga. He has published two or three short papers which causes me to believe he may become good in the years ahead. I hope to meet him sometime in the future.

Jadwiga Zlotorzyczna, of Warsaw, Poland, is another relatively new worker in the field of Taxonomy of Mallophaga. She has published several papers in the last few years and unfortunately their quality is poor.

Now a few words on each of the older workers who are still active. Some of them I met only through correspondence. L. R.

Guimarães, São Paulo, Brazil, is a slow careful worker. His papers on the Mallophaga found on Parrots are good generic revisions. He hasn't reviewed all the genera, but I hope he can complete the task.

Wolfdietrich Eichler has retired.

Theresa Clay continued to publish excellent reviews or revisions of Mallophaga genera found on birds until she retired in the early 1970's. In 1968, Stefan Von Keler submitted to an editor a revision of the Australasian Boopiidae. While it was being reviewed by the editor, Keler died. Theresa Clay and M. D. Murray redrafted the manuscript, which was published in 1971. After that Clay continued to work on mammal lice, while retaining her interest in bird lice. I hope she publishes a few more papers, even if she is retired.

João Tendeiro, a veterinarian teaching and doing research in Mozambique, started publishing Mallophaga papers in 1953; mostly on species found on African birds. He is a prolific writer and by the early 1970's was publishing revisions of genera found world-wide. He is now living in Lisbon, Portugal and has almost completed revision of all Philopterid genera found on doves and pigeons. While he was working on African Bird Mallophaga I sent him many specimens which I had obtained off birds in German museums. He described several new species from this material. Unfortunately when he and other Portuguese citizens were forced to flee Mozambique the specimens were lost. Future students, expecting to find these Holotypes in the U.S.N.M. will wonder where they are. I doubt they will ever be found.

In the mid-1950's Günter Timmermann, in Hamburg, Germany began a series of good papers dealing with Mallophaga found on Charadriiformes and Procellariiformes. The series continued in the 1960's and on into the early 1970's, until he became too ill to continue.

A few other names can be found in the literature of past few years, but those not mentioned above made minor contributions, or are not considered serious students of Mallophaga or Anoplura. It should be remembered the comments on each worker are my own opinions and observations and may not agree with those of other workers. The collections in the U.S.N.M. and my collection contain specimens studied and identified by those mentioned above, hence I thought it worthwhile to say a few words about each.

STATUS OF RESEARCH ON LICE

Research on new insecticides to control lice on humans and pets will not be discussed because the desire to eliminate populations on the hosts will continue to drive that problem. Control of lice on domestic livestock and poultry, is driven by economic considerations, so research for safer and better ways to eliminate the problems will drive research in that area. By dismissing these medical, veterinary and economic aspects from this discussion; the subject can be narrowed to the status of the taxonomy of lice (Anoplura and Mallophaga).

As more specimens from a larger variety of hosts became available, new species were discovered. New species required reevaluation of existing classifications. That process: description of new species, revision of genera, erection of new genera, proposing new classifications is still in process; and will continue for at least another decade. The process will continue longer unless more extensive field collecting occurs and more specialists enter the field. Both are unlikely to happen. To date, less than 25% of the species of birds and mammals have been examined for lice.

Life-cycle studies have been done for only a few species found on domestic animals and birds. Until more are done, we don't know what to expect. Perhaps we can find some answers to seasonal population dynamics which may affect distributions.

Mallophaga are parasitic on all species of birds and on some species of mammals, but not man. The life cycle, from egg through three nymphal stages to adult, is spent on the host. The ecological environments upon the host, which are relatively stable, determine the distribution of each species of parasite. The number of species of Mallophaga found on a bird will vary from two to more than ten, while the majority have five. The ecological niches occupied by the genera are: (1) the head and neck regions, where the lice tend to be short and fat-bodied and cling to the feathers with heavy mandibles, and where they are safe from the bird's beak; (2) the wing and back regions, where the lice tend to be long and slender with long legs to facilitate rapid movement across or through the feathers to avoid the bird's beak; and (3) rapid running forms found on the body, head, neck or wings which seldom attach firmly to feathers. Each ecological niche may be occupied by more than one species or genus. Two other ecological niches are also known, but they are so specialized that their occurrence is not widely distributed: inside the pouch of the Pelecaniform birds; and inside the large quills of birds in the orders Procellariiformes, Galliformes, Psittaciformes, and Charadriiformes.

Species in the sub-order Ischnocera are usually firmly attached to the feathers in ecological niches (1) and (2) and feed entirely on feathers. It is doubtful that these species are involved in the transmission of disease between hosts. Populations of lice, when

abnormally high, will denude some of the feather shafts, and cause intense irritation by their movement. Young and sick birds usually are more heavily infested than healthy adults.

Species in the sub-order Amblycera roam freely on the body and feed on blood, mucus, and serum. Some are equipped with piercing mouthparts, and others obtain blood from wounds created by their mandibles. Very little work has been done on the transmission of disease by these species but to date the following have been reported: (1) Intermediate host for a filarial worm in Swifts, cestode in dogs and a filarial worm in dogs; (2) Virus of Eastern Equine Encephalomyelitis has been isolated in a species of Mallophaga common on galliform birds; (3) *Bedsonia* organisms have been isolated in a species also on galliform birds.

The role or importance of Mallophaga in the transmission of disease between hosts remains to be explored. There has been little interest in this area, because they do not feed on man and are considered to be of little medical importance. So few people can properly identify Mallophaga that lice pooled for virus isolation usually are composed of those species which do not feed on blood. As interest in wildlife diseases increases, and more work is done on their epizootology, a better understanding of the role of Mallophaga in disease transmission will probably result.

Our present knowledge of the systematics of Mallophaga has reached the stage where it is very useful in assisting with the

development of a better understanding of the relationship of species or groups of species of birds. As birds evolved from a common stock, the Mallophaga also evolved, but at a slower pace. This occurred because the environmental change imposed upon the parasite was less than that imposed on the host. The food supply for the parasite (composition of the feathers, blood, serum, etc.) and the temperature and humidity of its environment probably remained more nearly stable than did the environmental changes which influenced change in the hosts. The picture is somewhat complicated by the fact that today we sometimes find both primary and secondary infestations of Mallophaga on a host species. This parasitism arose at different times in the evolution of the host and most specialists in Mallophaga can recognize these differences and so advise the ornithologist.

Most species of Mallophaga are restricted to a single species of host. Other relationships also exist between the parasites and the higher taxonomic categories. Examples of these are as follows: (1) A number of species are restricted to a single host genus rather than a single species of host. Examples are: *Trinoton aculeatum* Piaget 1855, a large body louse found on Tree Ducks of the genus *Dendrocygna*; and *Laemobothrion tinnunculi* (Linnaeus, 1758), a large body louse found on hosts of the genus *Falco* (Gyr Falcon, Falcon, Kestrel and Sparrow Hawk). (2) Birds of more than one genus, which obviously are closely related, may share a common parasite. *Ciconiphilus cygni* Price and Beer, 1965, a small body louse, is

found on the Swans (Mute, Whooper, Whistling and Trumpeter).

Ciconiphilus pectiniventris (Harrison, 1916) is found on Brants and Geese of the genera *Branta*, *Philacte*, *Anser* and *Chen*. In these two examples, hosts relationships above the generic level are evidenced by the lice they harbor. (3) Many genera of lice are restricted to hosts of only one family. However, only few species are widely distributed on hosts of a family. *Ciconiphilus decimfasciatus* (Boisduval and Lacordaire, 1835) is a small body louse found on Herons, Egrets and Bitterns of the genera *Ardea*, *Bubulus*, *Dichromanassa*, *Casmerodius*, *Egretta*, *Hydranassa*, *Nycticorax*, *Nyctanassa* and *Botaurus*. *Laemobothrion glutinans* Nitzsch, 1861 is a large body louse found on the Turkey Vulture, the Black Vulture and the California Condor. *Brueelia straminea* (Denny, 1842) is a wing shaft louse found on Flickers, Sapsuckers and Woodpeckers of the genera *Colaptes*, *Centurus*, *Melanerpes*, *Asyndesmus*, *Sphyrapticus* and *Dendrocopos*. In each example given, the relationship exhibited by a grouping of hosts into a family is confirmed by the lice. (4) The number of species of Mallophaga that can be found on hosts of more than one family within an order are few. *Ancistrona vagelli* (J. C. Fabricius, 1787) is a large body louse found on hosts of the order Procellariiformes. It has been found to date on hosts of the genera *Daption*, *Fulmar*, *Puffinus*, *Pterodroma*, *Pelagodroma* and *Oceanites*. *Ricinus marginatus* (Children, 1836) is a large body louse found on the hosts of families Cotingidae and Tyrannidae. It has been collected from hosts of the

genera *Platypsaris*, *Tyrannus*, *Muscivora*, *Myiarchus*, *Sayornis*, *Empidonax*, *Contopus* and *Pyrocephalus*. There are also a few species which may occur on hosts of more than one family in the Galliformes.

The influence of geography on the distribution of bird species is recognized; however, the influence of geography on the distribution of Mallophaga within the range of hosts is not well understood. The Barn Owl, *Tyto alba*, is found in many parts of the world. In North America, Australia, New Zealand and Southeast Asia it harbors *Strigiphilus aitkeni* Clay, 1966. In Europe, Africa and the Middle East it harbors *Strigiphilus rostratus* (Burmeister, 1838). We have no data on which parasite species appears in China, Japan and Siberia. The morphological differences between these two species of Mallophaga are far greater than those of the subspecies of *Tyto alba* found in these locations.

The Brown Booby, *Sula leucogaster*, and the Red footed Booby, *Sula sula*, both occur on the east and west coasts of North America. Regardless of where these hosts occur, they harbor *Eidmanniella albescens* (Piaget, 1880) and *Pectinopygus annulatus* (Piaget, 1880). In addition to these parasites, the birds found on the east coast harbor *Pectinopygus garbei* (Pessoa and Guimaraes, 1935), while those found on the west coast have *Pectinopygus sulae* (Rudow, 1869). This relationship exists even in Panama where the distance between flocks of the same species is not great. There are many other examples.

The commonest geographical relationship seen is that of a species limited in distribution to that of its host which has a restricted range.

In some way the size of the host may be a controlling factor in the type of Mallophagan infestation.

Species of the genus *Falcolipeurus* can be found on the quills of the primaries of the larger birds in the Falconiformes. Apparently members of the genus cannot survive on the smaller birds. Species of the genus have to date been recorded in North America from hosts of the Cathartidae, Accipitridae (*Rostrhamus*, *Aquila*, and *Haliaeetus*) and Falconidae (*Caracara*). Species within the genus *Falcolipeurus* are fairly host specific, but occurrence of a genus on hosts seems to be dependent upon host size since hosts of three families within the Falconiformes harbor these parasites.

Saemundssonina tringae (O. Fabricius, 1780) is a parasite found on the head and neck region of many small species of Charadriiformes. It has been recorded in North America from the host genera *Arenaria*, *Calidris*, *Erolia*, *Limnodromus* and *Ereunetes*. The list of hosts could probably be enlarged if collections were available from other small birds not listed.

Following domestication of a host its parasites may become less specific in their host relationships. The original host for *Menopon gallinae* (Linnaeus, 1758) apparently was the wild chicken. The original host for *Menacanthus stramineus* (Nitzsch, 1818) apparently was the wild turkey. Since domestication of these two hosts, both species can be found on any gallinaceous host raised in association with barnyard flocks. In some cases the two parasites may

occur in limited numbers on domestic ducks and geese. Also in some regions of the world these parasites are now established in many species of wild gallinaceous hosts.

A similar situation probably exists with the parasite *Colpocephalum turbinatum* Denny, 1842. This parasite, originally found on doves and pigeons, can now be found on kites, hawks, owls and eagles, where it is now established.

There is some evidence that host color may effect host selection by a parasite. Species of *Ardeicola*, found on the primaries of hosts of the order Ciconiiformes, appear to be host specific, with one exception. Recently it has been found that *Ardeicola expallidus* Blagoveshtchensky, 1940, a parasite first found on the Little Egret, *Egretta garzetta*, is also found on the Common Egret, *Casmerodius albus*; the Cattle Egret, *Bubulcus ibis*; and the Snowy Egret, *Leucophoyz thula*. The only criteria for this distribution apparently is color of the host.

Many mammals do not have Mallophaga; and those which do, harbor the parasites have fewer species than on the birds. The Mallophaga confirm that only one species of the Striped Skunk should be recognized, which most mammalogists agree. The lice indicate that only one species of Spotted Skunk exists in the United States, not several as the mammalogists currently propose.

Pocket Gophers, found in North America, and south through Panama, have been difficult to classify by mammalogists. The work

by Roger D. Price, and his co-workers, on the lice found on those mammals is proving useful in classification of the Pocket Gophers. The same is true for the Spiny Rats (genus *Proechimys*) found in the Neotropics. The lice apparently can sort the rat species easier than mammalogists can. This work also is not completed. The Hyraxes in Africa and the Middle East offer a similar challenge, and when enough Mallophaga are collected from all ranges of the Hyraxes (genus *Procavia*) then research on the Mallophaga may help the mammalogists.

In the Anoplura, we are finding that nymphs are of taxonomic value in determining species and relationships between species and genera. Nymphal morphology is also providing useful clues and data in Anoplura evolution. Dr. K. C. Kim is the leader in this research; and in the years ahead more research results based upon study of nymphs can be expected. Perhaps after nymphs from more species are studied, a better higher classification will be developed.

The role of Anoplura in the epizootology of diseases in wild animals is unknown. Until the lice used in transmission studies have been examined by a competent Anoplura Taxonomist to insure their identity and purity, we will have no worthwhile data. The common practice of pooling all ectoparasites, as is often the case in virology, produces no useful results.

Anoplura Taxonomists, especially those with good training in

mammalogy have much to contribute to a better understanding of the zoogeography of mammals; which also impacts on taxonomy of the mammals. Why do New World monkeys have lice in the same genus as the head and body lice? Does this mean that man brought his lice from Asia to the New World and they spread to the monkeys? Why do Old World monkeys have lice which are in a different genus? Which genus is more primitive? The Chimpanzee is the only Old World wild primate which has lice in the same genus (*Pediculus*) as the human head and body lice. The Gorilla is the only wild primate which has a species of pubic (or crab) (*Pthirus*) lice; the only other species in the genus is on man. Where did the genera *Pediculus* and *Pthirus* originate; on man, or on wild primates, or did they originate on a primitive primate from which man and the "great apes" evolved? We have seen no Anoplura from the Gibbon or the Orangutan, the only other "great apes." Perhaps when we can examine lice from these two primates some questions can be answered.

Dr. Joe T. Marshall found that data on the distribution of Anoplura species found on the different species of mice were valuable in his revision of the genus *Mus* species found in Southeastern Asia.

Rather than list other examples for mammalian hosts which have only Anoplura, there are other types of problems which are interesting. Why don't bats have lice? Why does the Peccary have Mallophaga (chewing lice) in South America and unique Anoplura (sucking lice) in the United States? Why do some species of New

World monkeys have Anoplura and others have Mallophaga? At the present time we don't have answers and may not have any until after extensive field collections are made and more lice are studied. However, without specimens to study we'll never know.

The list which follows shows which mammal families, or orders, have Anoplura and/or Mallophaga; and those host groups for which we do not have adequate collection data for either order of lice.

MAMMAL and LICE ASSOCIATIONS

<u>Mammals</u>	<u>Anoplura</u>	<u>Mallophaga</u>
MONOTREMES - Echidnas, Duck-billed Platypus	1	1
MARSUPIALS		
Didelphidae - Opossums	No	Yes 2
Dasyuridae - Marsupial "Mice"		Yes
Notoryctidae - Marsupial Moles		
Peramelidae - Bandicoots		Yes
Caenolestidae - "Rat Opossums"		
Phalangeridae - Phalangers		
Vombatidae - Wombats		Yes
Macropodidae - Wallabies, Kangaroos, etc.		Yes
INSECTIVORES		
Solenodontidae - Solenodons		Yes
Tenrecidae - Tenrecs		
Potamogalidae - Otter Shrews		
Chrysochloridae - Golden Moles		
Erinaceidae - Hedgehogs		
Macroscelididae - Elephant Shrews	Yes	
Soricidae - Shrews	Yes 3	No
Talpidae - Moles	Yes	No
DERMOPTERA		
Cynocephalidae - Flying Lemurs	Yes	
CHIROPTERA - Bats	No	No
PRIMATES		
Tupaiidae - Tree-shrews	Yes 4	
Lemuridae - Lemurs	Yes	
Indriidae - Indris, Sifaka		Yes
Daubentoniidae - Aye-aye		
Lorisidae - Loris		Yes
Galagidae - Bushbabies	Yes	
Tarsiidae - Tarsiers		
Cebidae - New World Monkeys	Yes 5	Yes 5
Callithricidae - Marmosets, Tamarins		
Cercopithecidae - Old World Monkeys	Yes	No
Pongidae - Apes	Yes	No
Hominidae - Man	Yes	No

<u>Mammals</u>	<u>Anoplura</u>	<u>Mallophaga</u>
EDENTATA		
Myrmecophagidae - Anteaters	No	No
Bradypodidae - Sloths	No	Yes
Dasypodidae - Armadillos	No	No
PHOLIDOTA		
Manidae - Pangolins	No	No
LAGOMORPHA		
Ochotonidae - Pikas	Yes	No
Leporidae - Rabbits, Hares	Yes	No
RODENTIA		
Aplodontidae - Mountain Beaver		
Sciuridae - Squirrels, Marmots, Chipmunks	Yes	No
Geomyidae - Pocket Gophers	No	Yes
Heteromyidae - Pocket Mice, Kangaroo Rats	Yes	
Castoridae - Beaver	No	No
Anomaluridae - Scaly-tailed Squirrels		
Pedetidae - Springhaas	Yes	No
Cricetidae - New World Mice, Hamsters, Gerbils, etc.	Yes	No
Spalacidae - Palaeartic Mole Rats		
Rhizomyidae - African Mile Rats, Bamboo Rats		
Muridae - Old World Mice and Rats, etc.	Yes	No
Gliridae - Dormice	Yes	No
Platacanthomyidae - Spiny Dormice		
Seleviniidae - Asian Dormice		
Zapodidae - Jumping Mice		
Dipodidae - Jerboas	Yes	No
Hystricidae - Old World Porcupines		
Erethizontidae - New World Porcupines	No	Yes
Caviidae - Cavies, Mara	Yes	Yes
Hydrochoeridae - Capybara		
Didomyidae - Paca-rana		
Dasyproctidae - Pacas, Agoutis, Acouchis, etc.	No	Yes
Chinchillidae - Chinchillas, Hutias, Coypu, etc.	Yes	Yes
Octodontidae - Bush Rats, Rock Rat, etc.	Yes	
Ctenomyidae - Tucotucos		Yes
Abrocomidae - Rat Chinchillas		Yes
Echimyidae - Spiny Rats, Arboreal Rats, etc.	Yes	Yes
Thryonomyidae - African Cane Rats	Yes	No
Petromyidae - African Rock Rats	Yes	No
Bathyergidae - African Mole Rats	Yes	
Ctenodactylidae - Gundis		

<u>Mammals</u>	<u>Anoplura</u>	<u>Mallophaga</u>
CETACEA - Whales, Dolphins, Porpoises	No	No
CARNIVORES		
Canidae - Dogs, Jackals, Foxes, Wolves	Yes 6	Yes
Ursidae - Bears		Yes
Procyonidae - Raccoons, Coatis, Pandas, etc.		Yes
Mustelidae - Weasels, Badgers, Skunks, Otters, etc.	Yes 7	Yes
Viverridae - Genet, Linsangs, Civets, Mongoose, etc.		Yes
Hyaenidae - Hyaenas, Aardwolf		Yes
Felidae - Cats, Lynx, Lion, Tiger, Leopard, etc.		Yes
PINNIPEDIA - Seals, Sealions, Walruses	Yes	No
TUBULIDENTATA - Aardvark	Yes	
PROBOSCIDEA - Elephants		Yes
HYRACOIDEA - Hyraxes	Yes	Yes
SIRENIANS - Dugongs, Manatees		
PERISSODACTYLA		
Equidae - Horses	Yes	No
Tapiridae - Tapirs		
Rhinocerotidae - Rhinoceroses		
ARTYIODACTYLA		
Suidae - Old World Pigs	Yes	No
Tayassuidae - Peccaries	Yes 8	Yes 9
Hippopotamidae - Hippopotamus		
Camelidae - Camels, Llama, etc.	Yes	
Tragulidae - Chevrotains		Yes
Cervidae - Deer, Moose, Elk, etc.	Yes	Yes
Giraffidae - Okapi, Giraffe		
Antilocapridae - Pronghorn		
Bovidae - Cattle, Bison, Goats, Sheep, Antelopes, etc.	Yes	Yes

Footnotes:

- Blank spaces indicate collecting has been inadequate to determine if parasites are found on these hosts.

2. No lice have been found on the Opossum found in the United States.
3. No lice have been collected off North American Shrews.
4. Lice suggest the Tree-shrews are more closely related to the Rodents than the Primates.
5. Some genera of New World Monkeys have Anoplura, others Mallophaga; to date both orders of lice have not been found on the same genus of Monkey.
6. Anoplura on Canidae represent a secondary infestation, originally from hooved animals.
7. Only Otters have Anoplura.
8. Peccaries in the U. S. and Northern Mexico have a unique species of Anoplura not found elsewhere.
9. Peccaries in the Neotropics have Mallophaga.

The theory of Continental Drift should be affected (one way or another) when we have good data on the Anoplura and Mallophaga from more species of mammals.

As in other areas of the Biological Sciences, Mallophaga and Anoplura Taxonomists are engaged in interesting, challenging research which is contributing to a better understanding of the World we live in. The unsolved problems seem to be numerous and will keep future generations busy trying to find answers.

THE ANOPLURA COLLECTION

IN THE U.S. N. M.

In the Fall of 1959 the Anoplura Collection was in excellent condition, because Dr. Phyllis T. Johnson, a U.S.D.A. scientist, had done extensive research on the order and prepared several papers prior to her departure. She continued her research on Anoplura, and published on the order, until 1973. The collection, in 1959, was in 121 tall 100-slide boxes and occupied 4 1/2 shelves in the standard steel-shelf units. Holotypes (or "cotypes") in the collection consisted of species described by:

O. G. Babcock and H. E. Ewing	1
H. E. Ewing	13
R. Fahrenholz	1
G. F. Ferris	1
P. T. Johnson (<u>in press</u>)	31
Herbert Osborn	4
H. D. Pratt and J. E. Layne	1
G. J. Rubin	3
R. A. Ward	1
Total	56

The Anoplura Collection had grown during the tenure of Dr. Johnson because of specimens provided by: Dr. Harry Hoogstraal with the Navy Medical Research Unit in Cairo, Egypt who was

collecting extensively in Egypt, Sudan and eastern Africa; Robert E. Elbel, U.S.O.M. Malaria Control Officer, an excellent collector, stationed in the Northeastern Provinces in Thailand; U. S. Army entomologists who collected rodent lice in Korea, Japan, and the Panama_Canal Zone; Colonel Robert Traub and his co-workers; and Dr. Wilbur Downs of the Trinidad Virus Laboratory.

There were several jars of vials, with Mallophaga and Anoplura in alcohol, in a wall cabinet. One had specimens provided by Dr. Wilbur Downs, another had specimens from the Panama Canal Zone provided by Lt. Col. Vernon J. Tipton and his co-workers. The remaining vials were mostly material sent to the U.S.D.A. for identification and were from domestic animals and common North American hosts.

During the past twenty years, the size of the Anoplura Collection grew more than 300 percent; and is now one of the best in the World. Present status and condition of the Anoplura Collection follows.

The Anoplura holotypes (etc.) are in 5 tall 100-slide boxes, each with a white back and a red border on the top and bottom. They are segregated by authors, and author names appear on the appropriate box. THESE SHOULD BE GIVEN FIRST PRIORITY IN CASE OF EMERGENCY EVACUATION. Holotypes (etc.) added to the collection since 1959 were described by these authors:

H. Fahrenholz	1
P. T. Johnson	15

K. C. Kim (including 3 <u>in press</u>)	11
K. C. Kim and K. C. Emerson	8
H. J. Kuhn and H. W. Ludwig	3
B. McDaniel	1
S. Van der Merwe	1
C. J. Stojanovich and H. D. Pratt	3
C. Weisser (in press)	4
C. Weisser and K. C. Kim	1
Total	48

Paratypes and non-type Anoplura are contained in 609 tall 100-slide boxes in steel-shelf units on the west and north side of room 450. They are arranged alphabetically by genus and species, without regard for family. It should be noted that paratypes are not segregated from the non-type specimens, as has been done with the Mallophaga.

There is a large quantity of Anoplura in vials which must be mounted on slides for study and incorporation into the collection. This unmounted material is mostly specimens collected in Africa from rodents. The longer it stays in vials, the more difficult it will be to prepare decent mounts. Most of the Anoplura obtained from Dr. William L. Jellison, Rocky Mountain Laboratory, Hamilton, Montana, have not been incorporated into the collection for lack of time to verify identifications. They are, however, included in the number of boxes given earlier.

This expansion occurred because extensive field collection efforts were funded by a number of agencies and organizations. Those funding the field collections will be discussed in some detail later. Most of the specimens collected were off rodents and other small mammals. Since most large mammals are now closely managed and protected, very few specimens from the large mammals were obtained. The areas collected, and the agency or organization funding most of the effort, are listed below:

1. Morocco - U. S. Army
2. Iran - U. S. Army
3. Pakistan - U. S. Army
4. Venezuela - U. S. Army
5. Africa, south of the Sahara - U. S. Army
6. Malaysia - U. S. Army
7. Indonesia (Java only) - U. S. Army
8. Taiwan - U. S. Navy
9. Philippines (Luzon only) - U. S. Air Force and U. S. Navy
10. Thailand - U. S. Army
11. Nepal - U. S. Navy

I obtained two small collections from U. S. Fish and Wildlife Personnel which were added to the collection. One was from Maryland small mammals, and the other from rodents collected in Oregon. In addition I was given a rather large collection of Anoplura collected in Nepal, from areas not covered by the U. S. Navy effort, and several collections made by W.H.O. personnel in Pakistan. Most of the small collections sent to me by individuals needing

identifications were placed in the collection. Dr. Robert Traub and Dr. K. C. Kim provided many specimens for the collection. Specimens sent to the U.S.N.M. or the Department of Agriculture for identification added almost nothing of value.

Probably the largest deficiencies in the collection are specimens from the hosts and areas listed below:

1. Australia and New Guinea
2. South America (except Venezuela)
3. Europe
4. North America
5. China
6. Siberia
7. Large mammals world-wide.

It is perhaps a surprise to most people, that less than one-half of the species of mammals in North America have been thoroughly examined for Anoplura. Many North American species of Anoplura in the U.S.N.M. collection are represented by less than 10 specimens.

In his forthcoming book on Anoplura, Dr. Kim and his co-workers will recognize at least 489 species. Of this number, there is type material for 145 (29%) of the species in the U.S.N.M. collection, and there are type material and non-type material for 308 species (63%). The number of valid species should be increased before his book is published, because of papers now in press. Type material for many of the unpublished papers is in the U.S.N.M. collection so the percentages represented in the U.S.N.M. collection should remain about the same.

THE MALLOPHAGA COLLECTION
IN THE U. S. N. M.

In the Fall of 1959, the Mallophaga Collection was stored in two small wooden desk-top containers with aluminum trays. Holotypes (or "cotypes") in the collection consisted of species described by:

M. A. Carriker	5
K. C. Emerson	15
H. E. Ewing	38
R. O. Malcomson	1
J. H. Paine	20
H. S. Peters	6
F. Simon	1
F. L. Werneck	4
Total	90

A number of paratypes of species described by Ewing, Paine, and Peters were present, but not counted at the time. Most of the paratypes were of species described by H. S. Peters.

The non-type specimens were not counted, but the number was less than 2,500.

My first actions were to remove the slides, which should be retained in the Collection and place them in short 100-slide boxes, and arrange them by family and genus.

Today, the Mallophaga holotypes (etc.) are in 26 short 100-slide boxes, each with a white back and a red border on the top and bottom. If the U.S.N.M. does not have the holotype of a species, and does have a paratype, it is stored with the holotypes. They are segregated by authors, and author names appear on the appropriate box. THESE SHOULD BE GIVEN FIRST PRIORITY IN CASE OF EMERGENCY EVACUATION. Holotypes (etc.) added to the collection since 1959 were described by these authors:

M. A. R. Ansari	18
H. C. C. Burmeister	1
M. A. Carriker	732
T. Clay	12
R. C. Dalgleish	3
R. L. Edwards	4
R. E. Elbel	12
R. E. Elbel and K. C. Emerson	1
K. C. Emerson	34
K. C. Emerson and R. E. Elbel	15
K. C. Emerson and J. C. Johnson	3
K. C. Emerson and H. D. Pratt	1
K. C. Emerson and R. D. Price	24
K. C. Emerson and C. J. Stojanovich	4
C. G. A. Giebel	4
L. R. Guimaraes	3

W. W. Hill and D. W. Tuff	2
G. H. E. Hopkins	1
W. L. Jellison	1
S. von Keler	6
H. F. Klockenhoff	4
J. A. Ledger	2
S. A. Le Souëf and H. Bullen	1
E. Mendez	5
H. Osborn	8
A. S. Packard	1
R. D. Price	22
R. D. Price and J. R. Beer	30
R. D. Price and T. Clay	1
R. D. Price and K. C. Emerson	20
F. Rudow	2
F. P. Schrank	1
E. W. Stafford	3
B. K. Tandan	9
Joao Tendeiro	40
G. Timmermann	5
D. W. Tuff	9
R. A. Ward	2
J. S. Wiseman	3
Total	1,085

In addition to the above are 46 slides of Kellogg material which are "cotypes" or syntypes.

The remaining Mallophaga paratypes are stored in 128 short 100-slide boxes, each with a white back and are segregated by authors, with author names on each box.

All Mallophaga type material is stored in the bookcase on the south wall of room 450.

The non-type Mallophaga are stored in 1,017 short 100-slide boxes in steel-shelf units along the north wall of room 450. At the rate the collection is expanding more boxes will be added later this year. The specimens are separated by family and arranged alphabetically by genus and species in each family (the sole exception is the genus *Trichophilopterus*, family Philopteridae, which is in the same case with other species found on mammals).

A large amount of vial material should be mounted, because storage in alcohol for extended periods results in poor slides; often too poor for detailed study.

In the past twenty years, the Mallophaga Collection has grown twenty-fold and is still growing. This spectacular growth resulted from these gifts:

- 1) M. A. Carriker's Collection of Neotropical
Bird Mallophaga.
- 2) Rocky Mountain Laboratory Collection.
- 3) Communicable Disease Center Collection.

- 4) Specimens from the K. C. Emerson Collection.
- 5) Dr. Robert E. Elbel's Thailand Collection.

As with the Anoplura Collection, Mallophaga were added from field collections funded by these agencies or organizations:

- 1) Mammal Mallophaga from Uruguay- - U. S. Army.
- 2) Mammal Mallophaga from Venezuela - U. S. Army.
- 3) Bird Mallophaga from the Western Mediterranean Area - Department of Defense.
- 4) Mammal Mallophaga from Bolivia - U. S. Army, N.I.H.
- 5) Mammal Mallophaga from Malaysia - U. S. Army.
- 6) Bird Mallophaga from Islands in the Pacific Ocean - U. S. Army.
- 7) Bird Mallophaga from Japan, Korea, Taiwan, Hong Kong, Malaysia, Thailand and India - U. S. Army.
- 8) Bird and Mammal Mallophaga from Nepal U. S. Navy
- 9) Bird and Mammal Mallophaga from Taiwan U. S. Navy.

More details on these collections will be provided later.

Very few specimens were sent to the U.S.N.M. or U.S.D.A. for identification of species that were added to the collections.

During the past twenty years I have received specimens, at my home, from more than 1,500 individuals and organizations (world-wide) requesting identifications. By giving prompt identifications, which were often needed for publications, many sent me Mallophaga for years. Specimens surplus to my collection were added to the

U.S.N.M. Collection and the numbers given are in the Annual Reports of the U.S.N.M.

As in the Anoplura, the Mallophaga Collection is woefully short in many areas:

- 1) North American birds and mammals.
- 2) South American mammals (except Venezuela).
- 3) South American birds, south of the Amazon River.
- 4) European birds and mammals.
- 5) African birds and mammals.
- 6) Australian birds and mammals.
- 7) Mid-eastern birds and mammals.
- 8) Asian birds and mammals (north of Thailand, India, and Nepal; and west of Korea)
- 9) Central American mammals.

Carriker's collection of Mallophaga found on Tinamous (small quail-like birds found in Neotropical Areas) now in the U.S.N.M. Mallophaga Collection, probably contains representatives of 95% of the known species. I estimate that about one-half of the remaining described species are represented in the U.S.N.M. Mallophaga Collection. The unidentified Mallophaga probably contain specimens representing at least 100 new species. Most of the unidentified material is from passeriforms (song-birds) and the genera concerned all need review or revision. At present, no one is prepared to undertake these enormous tasks.

As in the Anoplura, the percentage of North American species represented in the U.S.N.M., is too low.

MEDICAL ENTOMOLOGY

AND

THE ARMED FORCES

In February 1961, I was appointed Assistant for Research, on the staff of the Secretary of the Army; with responsibility for all research conducted by the Army, either by in-house personnel or on contract. I retired as an officer on October 31, 1966 and on November 1, 1966 was sworn in as a civilian, and continued in the same capacity until November 21, 1978 when I again retired. During the Nixon Administration my title was changed to Deputy for Science and Technology, but my responsibilities were unchanged. While a civilian, I was often Acting Assistant Secretary of the Army; the longest period was for six months during the Ford Administration.

During World War II, in the South Pacific Theater of Operations, the U. S. Army had an average annual disease rate of 671 per 1,000 soldiers. This rate includes only soldiers admitted to hospitals for treatment. The rate of ineffectives (men unable to perform duties or man days lost) was probably double this rate, if those not admitted to hospitals were included in the data.

Some of the research in preventative medicine during the Korean War and afterwards suggested this rate could be reduced. During the Viet Nam War, the annual disease rate, for those

admitted to hospitals was only 351 per 1,000 soldiers. Many research programs contributed to this dramatic reduction. I will discuss, in summary form, only portions of some research programs which added to our knowledge of insects of medical and veterinary importance.

The physical and engineering sciences, with American manufacturing procedures and techniques can develop and produce new weapons and materiel as required. The Life Sciences can provide the knowledge which enhances man's ability to survive in hostile environments. However, prior to the late 1950's, the Life Sciences, except for a few specialities in medicine were not provided funds adequate to explore hostile environments that U. S. personnel would encounter when deployed in most areas in the world. Robert Traub and Vernon Tipton, two of the Army's finest entomologists, started working on the ectoparasites in areas outside the U. S. in the late 1950's. Those two published several volumes on ectoparasites, in addition to many papers in scientific journals. Robert E. Kuntz and Harry Hoogstraal of the Navy were doing the same in other areas outside the U. S. Harry Hoogstraal has been a prolific author, publishing many books and scientific papers on ticks. Ken Knight, Stanley J. Carpenter and Walter J. LaCasse were working hard on the mosquito taxonomic problems, as were former officers John Belkin and Lloyd Rozeboom.

When it became evident that sometime in the future the U. S.

might deploy troops into Viet Nam, Army specialists went into Southeastern Asia to determine diseases, vectors, etc. that might be problems. After they returned, research was initiated, where needed, which might help reduce losses from diseases. I realize this is an over-simplification, but it is sufficient to explain why the Army (Navy and Air Force) obtained thousands of insects for study.

Our knowledge of mosquitoes proved to be particularly deficient, and is today; so the Army is still engaged in a contract program with the Smithsonian Institution to help improve our identification, ecology and distribution data of mosquitoes worldwide.

Many diseases of birds and mammals are also diseases of man, and these diseases vary in different areas of the world. Hosts and vectors may vary in different parts of the world, and new diseases are being discovered every year which involve insects and wild animals (birds and mammals) and transmission of the diseases to man. I felt that any area, regardless of the current political situation, for which there was inadequate preventive medicine information, should be considered for research. The Armed Forces could be deployed anywhere in the world on short notice, and they should have the knowledge needed to minimize risk to their health.

As funds and personnel became available, programs were

initiated to obtain information by in-country collecting. In some areas we were able to obtain specimens and data before the political situation changed, or became no longer safe for U. S. personnel. Fortunately in some areas we were able to obtain specimens and data by providing some funds to local scientists on a cooperative basis. Since all the data and research results were concerned only with unclassified data; results were of equal benefit to local scientists and governments. In many cases agreements were made which resulted in sharing of specimens collected, which improved local museums. In most countries, the number of specimens collected was enough so that a portion could be distributed to several museums. So today many museums have specimens collected during the 1960's and 1970's as part of this program. In one country, the U. S. Army paid publication costs, so that a competent local scientist could publish data he had collected for 40 years. He could not obtain funds locally to publish his findings.

Identification of specimens was done by scientists throughout the world, regardless of nationality, and they were encouraged to publish results and retain duplicate specimens for their collections. It will be several years more before all results of these collection efforts are published.

As mentioned earlier, the Anoplura papers published in the 1960's by Phyllis T. Johnson were based largely on specimens collected in Northern and Eastern Africa as part of a U. S. Navy

program. Some Anoplura and Mallophaga collected in that program are in the U.S.N.M. Collections. The ticks are in the National Tick Collection at Rocky Mountain Laboratory, Hamilton, Montana.

The effort devoted to collection of ectoparasites varied greatly between programs (or projects), and in some instances it was merely a small "add-on task" involving only a small increase in funding. Some collections were made by personnel in the Armed Forces, and others were made by other organizations under contract.

Specimens from these collection efforts can now be found in many museums in the Free World, and in collections of specialists who made the identifications. So that future workers will know the origin of the hundreds of thousands of specimens they are studying, I am listing the areas collected, and who provided the funding. To date hundreds of thousands of bird, mammal, and insect specimens were collected, and now are available for study.

U. S. Navy - Egypt, Libya, Sudan, Kenya,
Ethiopia, Nepal, Java, and Taiwan.

U. S. Air Force - Philippines (only on Luzon).

U. S. Army - Africa (south of the Sahara), Iran,
Thailand, Pakistan, Algeria, Venezuela,
Malaysia, Panama, Costa Rica, Uruguay, and
Islands in the Pacific Ocean.

Department of Defense - Zaire, and the Eastern
Mediterranean Area.

U. S. Army and National Institutes of Health -
Panama and Bolivia.

U. S. Army and Scientists in Countries listed -
Japan, Korea, Taiwan, Hong Kong, Malaysia,
The Philippines and India.

Collection projects in Southern Africa, Morocco, Venezuela, Iran, and islands in the Pacific Ocean were accomplished by contracts between the U. S. Army and the Smithsonian Institution. Under these contracts, the project leaders, Dr. Henry Setzer and Dr. Charles Handley, received their normal salary from the Smithsonian; all other expenses were paid by the Army. Large mammal, in addition to the insects, collections were accumulated, which now are in the U.S.N.M.

The above are examples of one extreme in funding by the Armed Forces. At the other end of the scale was funding provided for direct supply, labor and transportation costs incurred by the added task of collecting ectoparasites. In all cases, the returns for funds expended exceeded expectations. Data were obtained to meet needs at the time; and with proper care, these specimens will also be available for future generations of scientists to study. They are now a national asset.

ECTOPARASITES
IN
THE K. C. EMERSON ENTOMOLOGY MUSEUM
Oklahoma State University

By 1970 I had sorted through my personal collection of ectoparasites and provided duplicates to the U.S.N.M.. The British Museum (Natural History) and other museums; and decided it was still too big. At that time, it also occurred to me that I should do something for my Alma Mater, so I offered my collection of ectoparasites to Oklahoma State University. Several schools and museums were interested in buying or receiving it as a gift, but because Oklahoma State University was my Alma Mater and was one of the leading universities providing medical entomologists for the Army, it was a logical choice. The Board of Regents named the entomological portion of the University Museum - The K. C. Emerson Entomology Museum -, and agreed that if any specimens given by me, are destroyed, lost or exchanged, the entire gift reverts to my heirs. Each slide in the collection has a serial number. I asked for this agreement to insure the collection was safeguarded and maintained for use by future workers. Also, I felt that additional specimens in the U.S.N.M. or the British Museum would not be as useful as a good collection in that part of the United States and University that I love.

The Anoplura and Mallophaga portions of the collection are excellent. None of the species in each order are represented by large series, and there are no Holotypes. Most of the species of Anoplura in the U.S.N.M. Collection are also represented in my collection. The same is true of the Mallophaga portion, except for the species found on Tinamous. Carriker's Tinamous material in the U.S.N.M. probably can never be matched. My collection contains some representatives of Old World species not found in the U.S.N.M. Collection. The Anoplura and Mallophaga species which are identified are now at Oklahoma State University. Unidentified material is still in my home. In both orders, the number of specimens collected in Oklahoma are few, because most of my Oklahoma material was lost in the Philippines. Unless a student needs to examine Holotypes, or is working on the Mallophaga found on Tinamous, study of Anoplura and Mallophaga can be done as well at Oklahoma State University as at the U.S.N.M.

Part of my Siphonaptera specimens have been moved to Oklahoma State University. The remaining specimens will be shipped during the next two years. It is a good collection, but certainly not as large or complete as several in the United States. Because there were several good researchers working on fleas, I did not expend a lot of time or effort in trying to obtain a complete collection. I did collect all fleas encountered while collecting in the field, and obtained duplicates from my friends when they had some extras.

Anyone collecting lice and fleas can be expected to obtain a few Pupipara (parasitic Diptera on birds and mammals). As in the Siphonaptera, I kept examples of species which came my way; either by my collection efforts or sent me by others. A box of slides for each family provides enough for students to begin research on the group. The same situation pertains to Cimicidae and Polytenidae (parasitic Hemiptera). The number of ticks and parasitic mites is very small.

As of the date this manuscript was written (April 1979) no student or member of the faculty has provided me with any specimens to be identified and added to the Collection. Perhaps it is best that it happened this way, so my contribution could be clearly identified.

ACKNOWLEDGMENTS

This paper was written for historical, professional, institutional, educational and personal purposes. C. F. W. Muesebeck and Paul and Phyllis Spangler urged that it be done so that those who follow me in the U.S.N.M. will know the origins of the current collections. I thought that rather than write a separate paper on the collection at Oklahoma State University, the logical solution was to include information on it in this paper. Robert Traub suggested I discuss the status of research on the lice. Several people, Mr. Muesebeck and some of my former students and co-workers, thought, since I knew so many of the workers in the field, that the history of Mallophaga and the participants should be recorded. Perhaps other entomologists will do the same with their fields of interest.

My three sons are in professions other than Entomology or Biology. They know I enjoyed working with ectoparasites; but know little about the subject. Perhaps this account will give them an appreciation of why I found my research to be fascinating, and they will understand that some of the rewards are contained in the attached list.

My work could not have been done without the help of more than 1,500 people who sent me specimens they collected; and the hundreds who exchanged or gave me slides of specimens from their collections.

I thank them all. I also am thankful for the opportunity to work with so many wonderful people, who also shared my interest in ectoparasites, ornithology, mammalogy, parasitology and ecology.

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BY

K. C. EMERSON

Attached is a list of my published entomology papers and books, which also shows the new forms described. These and other papers in press, or which will be published in the next few years, will be reviewed by future workers. They must evaluate their worth and contributions.

Those who do not study how modern Mallophaga Taxonomy developed may not appreciate the role several of us had in bringing about the change. Unfortunately we could be criticized for not doing it earlier, without realizing, how much work was done by so few.

My four volume Checklist of Mallophaga of North America, published in 1972 is the only useful reference available on the subject. Unfortunately Volume IV was not proof-read before publication and contains too many errors, however it has helped many people. I hope to have a revision out in 1982.

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(*Geomydoecus costaricensis* n. sp.)
(*Geomydoecus dakotensis* n. sp.)
(*Geomydoecus dariensis* n. sp.)
(*Geomydoecus duchesnensis* n. sp.)

(*Geomydoecus ewingi* n. sp.)
 (*Geomydoecus fulvescens* n. sp.)
 (*Geomydoecus geomydis subgeomydis* n. ssp.)
 (*Geomydoecus ionesi* n. sp.)
 (*Geomydoecus illinoensis* n. sp.)
 (*Geomydoecus mcgregori* n. sp.)
 (*Geomydoecus merriami* n. sp.)
 (*Geomydoecus mexicanuz* n. sp.)
 (*Geomydoecus neocopei* n. sp.)
 (*Geomydoecus oklahomensis* n. sp.)
 (*Geomydoecus oregonus idahoensis* n. ssp.)
 (*Geomydoecus oregonus oregonus* n. ssp.)
 (*Geomydoecus panwnensis* n. sp.)
 (*Geomydoecus perotensis irosonis* n. ssp.)
 (*Geomydoecus perotensis perotensis* n. ssp.)
 (*Geomydoecus polydentatus* n. sp.)
 (*Geomydoecus quadridentatus* n. sp.)
 (*Geomydoecus subcalifornicus* n. sp.)
 (*Geomydoecus tolucae* n. sp.)
 (*Geomydoecus traubi* n. sp.)
 (*Geomydoecus trichopi* n. sp.).
 (*Geomydoecus umbrini* n. sp.)
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 (*Gliricola handleyi* n. sp.)
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