FREDERICK A. G. MUIR

Biographical Sketch
The Work of Dr. Frederick A. G. Muir in the Biological Control of Sugar Cane Insects in Hawaii

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With the death of Dr. Muir in England on May 13, 1931, ended the career of a man who had devoted his best years to the field of biological control as a method of controlling insect pests. Dr. Muir began this work for the Experiment Station of the Hawaiian Sugar Planters' Association in September, 1905. This was when the sugar cane leafhopper (*Perkinsiella saccharicida* Kirk.) was still a serious pest in Hawaii. It was also shortly after the introduction of the leafhopper egg-parasites* by Albert Koebele and Dr. R. C. L. Perkins, from Australia and Fiji. These parasites had not yet shown their ability to cope with the enormous numbers of their host. Mr. Koebele had been working for more than ten years on the introduction of beneficial insects into Hawaii and, being in failing health, wished to retire from active foreign work in the tropics. On his return from Fiji he spent but a short time in Honolulu in the summer of 1905, before leaving for California. Mr. Koebele never came to Honolulu again.

To carry on the work in which Mr. Koebele had been so successful since his arrival in Hawaii in 1893, Dr. Muir was engaged, and his services on the staff of the Experiment Station, H.S.P.A., commenced September 1, 1905.

Spending but a short time in Honolulu, Dr. Muir's first foreign trip was to Fiji with the primary object of investigating the economic conditions of the leafhopper in cane fields there. This leafhopper was a different species from the cane leafhopper in Hawaii and was found doing no damage to cane, being kept in check by several natural enemies, the most important of which were the egg-parasites mentioned above and which had already been introduced into Hawaii. Another parasite found to have economic value was a stylopid (*Elenchus tenuicornis* Perk.). Attempts were made to introduce this parasite into Hawaii, but it

* *Paranagrus optabilis* Perk., *P. perforator* Perk., and *Anagrus frequens* Perk., from Australia in 1904; and *Ootetrastichus beatus* Perk. from Fiji in 1905.

failed to attack the leafhopper in the cane fields there. Still another parasite found was a dryinid (*Haplogonatopus vitiensis* Perk.) which was successfully introduced into Hawaiian cane fields, and for a time was quite a factor in the control of the leafhopper. After a number of years, however, it became scarce and in recent years has been seldom seen.

On this trip a great deal of time was spent in investigating the cane borer (*Rhabdocnemis obscura* [Boisd.]) to discover if possible the cause of its decrease there, for Mr. Koebele had reported such a decrease in Fiji since his visit there in 1892. No natural enemies were found that could be considered responsible for this. Some of the planters believed that the introduction of a harder variety of cane was the chief reason for the decrease of the borer. After six months in Fiji, Dr. Muir returned to Honolulu, where a few months were spent prior to starting off in July, 1906, for the Orient, where cane leafhopper parasites were investigated in south China in the vicinity of Macao, and inland from Canton. Cane leafhoppers there were found well controlled by egg-parasites similar to those in Australia and Fiji, and there were other valuable enemies as well. Only one of these was successfully introduced into Hawaii. This was a large black dryinid (*Pseudogonatopus hospes* Perk.), parasitic on adult leafhoppers. It was reared at the Experiment Station and colonies were distributed to the other islands, but it was only after nine years that it was known to have become established in Hawaiian cane fields. It never became very numerous, but even in recent years with the leafhopper usually scarce, this parasite maintains its existence, and an occasional parasitized leafhopper is to be found usually wherever any leafhoppers occur.

In February a brief visit was made to the Federated Malay States where conditions as regards leafhoppers and their enemies were found to be about as in China. A search was begun for the cane borer beetle, which was continued in Java; Dr. Muir arrived at Batavia on March 10th and spent several months in the different sugar cane sections of Java, without finding any evidence of our cane borer beetle, or any direct parasites on related beetles in banana and palm trees.

On July 21, he left Java for a few weeks' search for the borer in Borneo, returning to Batavia in September, from which place

another start was made in October, 1907. The search for the natural home of the beetle borer was continued in Amboina and Larat, where at last this insect was found in sago and pinang palms and in sugar cane. No success was had in finding parasites for several months, however. Finally, in January, 1908, a tachinid fly* was found attacking the grubs or larvae of this borer. Eight months were then spent at Amboina in studying this parasite and breeding it for shipment to Honolulu; but as the parasite could not survive such a long journey, attempts were made to establish a relay station at Hongkong. This station, which was to have been conducted by F. W. Terry, was not successful as the tachinids always died en route. Finally, Dr. Muir tried taking living material with him to Hongkong, but the flies all died the day before his arrival. This venture having failed, Dr. Muir left Hongkong in November, 1908, for further explorations, visiting Ceram and Makassar, en route to New Guinea, where he landed at Port Moresby in April, 1909. Here for the first time, the tachinid parasite, that was breeding so well on the borer grubs in palm trees at Amboina, was found attacking a high percentage of the borer grubs in sugar cane. At once preparations were made for stocking cages with borer-infested cane in which the borers were to be parasitized, and then brought to Honolulu. Several months were required for this, and when eventually the cages were in readiness for the long journey, Dr. Muir fell ill with typhoid fever just prior to leaving Port Moresby, New Guinea, so that on arriving at Brisbane, Queensland, he was compelled to go to a hospital where he remained for five weeks. His cages were forwarded to Honolulu, arriving there September 15, 1909. Over 200 of the tachinid flies had matured en route, but, lacking the personal care that had been planned for them, all had died before their arrival in Honolulu. Thus is recorded another failure in the introduction of this parasite.

As soon as he had recovered sufficiently in the Brisbane hospital, Dr. Muir came on to Honolulu for further recuperation, arriving about the end of October, after an absence from Honolulu of three years and three months, most of which time was spent in tropical jungles where he was exposed to the dangers from wild animals, venomous snakes and insects, as well as to tropical diseases prevalent in those regions.

*_Ceromasia sphenophori_ Vill.

At once plans were made for further attempts to introduce this parasite on the cane borer. Dr. Muir left Honolulu, January 8, 1910, on the final endeavor which resulted in the transportation of the living parasite to Honolulu and its establishment in the cane fields of Hawaii. The procedure this time was the establishing of a relay breeding station at Mossman, Queensland, cared for by Mr. J. C. Kershaw. In cages here the tachinid was bred from material brought by Dr. Muir from New Guinea. Of the first generation of parasites reared in these cages, a portion was taken in the puparium stage to Fiji, where at Nausori another relay breeding station was established. From the next generation of parasites produced here, living material was brought to Honolulu by Dr. Muir on August 16, 1910. Mr. Kershaw arrived a month later with more material reared in Fiji. From both of these lots there were sufficient adult parasites to allow some to be liberated in a few cane fields, while others were retained for breeding in cages. Altogether, over four years were occupied on this project; from the beginning until living parasites were landed in Honolulu. The results obtained in checking the cane borer after the parasite was established and fully distributed, more than justified the time, effort and expense involved.

Staying a short time, until the breeding of the tachinid was well started, Dr. Muir sailed from Honolulu, October 4, 1910, for a well-earned leave, going to England for a year, and returning to Honolulu, October 11, 1911.

The next large project undertaken by Dr. Muir, was the endeavor to find and introduce natural enemies of the cane root grub, *Anomala orientalis* (Waterhouse), which in 1912 was found established in cane fields in the Pearl Harbor district of Oahu. There was little or no encouragement to be had from previous efforts to control root grubs by natural enemies in other parts of the world. However, after duly considering the situation, Dr. Muir believed that an attempt should be made to control the spread of Anomala in our cane fields by this method. He left Honolulu for Japan, March 28, 1913, that country being the home of *Anomala orientalis*. A number of valuable natural enemies were found working on Anomala there and efforts were made to introduce some of them here, but none ever became established. After about a year in Japan, search was made in Java, Formosa

and the Philippines for parasites of closely related species of root grubs that might possibly be utilized against Anomala. The breaking out of the World War disturbed transportation from those regions, and it was found that the Philippines were the most favorable place in which to work and to secure dependable transportation for consignments of parasites. A large number of root-grub enemies were studied in the Philippines, headquarters being established at the College of Agriculture at Los Banos, where every facility for the work was rendered. Dr. Muir was assisted in the work here by Mr. H. T. Osborn and Dr. F. X. Williams, and large quantities of some of the parasites were reared for shipment to Honolulu, and many consignments were made during 1915, 1916 and 1917.

Of the numerous parasites of several kinds that were handled, *Scolia manilae* Ashmead, the wasp which parasitizes the Anomala grub was the only one to become established in our cane fields. It was first found established and breeding on Anomala grubs September 16, 1916. In the four years since its discovery, Anomala had spread over a considerable area of cane land adjacent to Pearl Harbor. As soon as Scolia was found established in one field, assistance was given it in spreading throughout the Anomala-infested area. This was accomplished during the next year, and the wasp proved so efficient that attempts to introduce additional parasites on Anomala were discontinued. This project turned out to be the first successful control of a root grub by means of natural enemies.

During the four years involved in this work, Dr. Muir returned to Honolulu once or twice; on one trip, coming via Formosa, he brought some leafhopper egg-parasites, one of which (*Ootetrastichus formosanus* Timberlake) became established and spread throughout the cane fields of the islands and was an additional factor in the control of the sugar cane leafhopper. It persists to the present time, even where the leafhopper is normally scarce.

On October 31, 1917, Dr. Muir left for England to engage in war service for his native country in the trying days of the World War. He returned to Honolulu a year later on October 28, 1918. In the meantime he had married Margaret Annie Sharp on April 9, 1918, the daughter of Dr. David Sharp, the noted entomologist

who contributed much to the study of Hawaiian insects and to the Fauna Hawaiiensis. Mrs. Muir accompanied Dr. Muir on his return from England, and also on his last trip in search of parasites to Australia, which was begun early the next year.

Although there now existed a fairly satisfactory control of the sugar cane leafhopper by the introduced parasites previously mentioned, nevertheless in a few plantations there were recurrences of leafhopper outbreaks which were of considerable importance. The purpose of Dr. Muir's last trip May 18, 1919, to June 21, 1920, was to endeavor to find what additional factors controlled the leafhopper in the Queensland cane fields. After considerable research, he found that a small bug, *Cyrtorhinus mundulus* (Breddin), of the family Miridae, lived by sucking the contents of the eggs of the leafhopper. The introduction of this bug into Hawaii was soon accomplished, chiefly from Fiji (where it was known to occur), by Mr. C. E. Pemberton the following year, September to November, 1920. This bug was reared and colonies distributed for a year, and from thereafter when it became thoroughly established, the control of the leafhopper pest in Hawaiian cane fields was practically complete. There have been slight outbreaks occasionally, but the Cyrtorhinus bug was always prompt to find them, and would soon increase to numbers sufficient to regain control. It has been thought that if this bug had been the only leafhopper enemy introduced it might of itself have been able to sufficiently control the leafhopper.

The total results of the major introductions above enumerated have been the saving of millions of dollars to the sugar industry in Hawaii, and the comparative freedom from destructive insect pests in the cane fields.

After returning from the last trip to Australia, Dr. Muir established his home in Honolulu. Much of his time was now devoted to systematic studies in Homoptera, particularly the Fulgoroidea. This is the group which contains the family Delphacidae to which the cane leafhopper belongs. In his travels Dr. Muir made a specialty of studying and collecting sugar cane leafhoppers as well as other related leafhoppers. Many species of these were named and described by him in numerous papers included in the bibliography which follows. He became intensely interested also in the leafhoppers of the forests of Hawaii, and

added many species to those already known, these new species of the Hawaiian fauna being published in the Proceedings of the Hawaiian Entomological Society. Dr. Muir eventually devoted himself to the study of leafhoppers the world over, and was recognized as a world authority on the leafhoppers of the family Delphacidae. Just before his death he was planning to work up a large collection from South America.

Dr. Muir's health had been undermined by so much time spent in unhealthful tropical jungles, etc., and he went to England at intervals, spending most of the years 1927 and 1928 there. On his return from England, September 12, 1928, arrangements were made for his retirement from active service at the Experiment Station, H.S.P.A. He left Honolulu on November 17, 1928, to make his home in England, and had made preparations for carrying on systematic work there in his favorite family of leafhoppers, which work, however, he was not able to pursue because of his failing health.

PUBLISHED WRITINGS OF DR. F. A. G. MUIR

In the Hawaiian Planters' Monthly and Hawaiian Planters' Record.

1908. Report of travels in Borneo in search of cane borer parasites. Planters' Monthly, XXVII, pp. 50-57.
1908. Report on the search for the sugar cane borer in the Malay Archipelago. XXVII, pp. 252-257.
1909. Report on the sugar cane borer in the Moluccas. Planters' Record, I, pp. 40-48, 1 map.
1909. Concluding report on travels in the Malay Archipelago in search of parasites for the cane borer. I, pp. 256-261.
1910. Report on second trip to British New Guinea to obtain a tachinid fly, parastic on the sugar cane beetle borer. III, pp. 186-200, 5 pls.
1914. Observations in Formosa. X, pp. 274-281.
1915. The relation of the parasite to its host. XIII, pp. 118-125, 1 diagram.
1917. Remarks on leaf-hopper outbreaks. XVII, pp. 227-230.
1919. The use of insecticides against leaf-hoppers. XX, pp. 171-172.
1919. Leaf-hopper infestation in plant cane. XX, pp. 380-381.
1920. Report of entomological work in Australia, 1919-1920. XXIII, pp. 125-130, 1 fig.
1920. The "Japanese" beetle is Chinese. XXIII, p. 291.
1921. Cyrtorhinus in Hawaii and some factors acting against it. XXIV, pp. 285-286.
1921. The fern weevil in Australia. XXV, pp. 2-3.
1922. Direct and indirect injury to plants by insects. XXVI, pp. 65-66.
1922. Earthworms and their culture in relation to agriculture. XXVI, pp. 159-163.
1931. The biological control of the coconut moth (*Levuana iridescens* Beth.-Baker) in Fiji. XXXV, pp. 85-87.

Co-authorship

Muir, F., and Henderson, G. 1926. Nematodes in connection with sugar cane Root Rot in the Hawaiian Islands. XXX, pp. 233-250, 14 figs.

Muir, F., Henderson, G. and Van Zwaluwenburg, R. H. 1927. A generic list of the spear-bearing nematodes with a revised dichotomous table. XXXI, pp. 354-361.

Muir, F., and Swezey, O. H. 1926. Entomologists' Report on Termite Problem. XXX, pp. 331-335.

Muir, F., and Van Zwaluwenburg, R. H. 1927. The bad effect of leaf pruning upon the growth of stalk and root of sugar cane. XXXI, pp. 110-112, 2 figs.

Stewart, G., Muir, F., Van Zwaluwenburg, R. H., Cassidy, G. H., and Hansson, F., 1928. The relation between soil treatments and nematode attacks to cane roots in central Maui soils. XXXII, pp. 205-217.

As Bulletins or Circulars of the Experiment Station, Department of Entomology, Hawaiian Sugar Planters' Association

1906. Notes on Some Fijian Insects. Bull. 2, pp. 1-11, 1 pl.
1907. Report on Investigations in South China. Circular No. 1, pp. 1-11.
1907. Notes on the Sugar-Cane Hoppers and Borers in the Malay States and Java. Circular No. 2, pp. 1-13.
1908. Entomological Work in Borneo. Circular No. 4, pp. 1-12.
1910. On Some New Species of Leafhopper (*Perkinsiella*) on Sugar Cane. Bull. No. 9, pp. 1-11, 5 figs.
1926. Contributions to our Knowledge of South American Fulgoroidea (Homoptera) Part I, The Family Delphacidae. Bull. 18, 51 pp., 5 pls.
1931. The Insects and Other Invertebrates that occur in Hawaiian Sugar Cane Fields. Introduction. pp. 11-32.

Co-authorship

Kirkaldy, G. W., and Muir, F. 1913. On Some New Species of Leafhoppers. (Part I *Cicadidae, Cercopidae* and *Fulgoridae* by Kirkaldy; Part II *Derbidae* by Muir). Bull. No. 12, pp. 28-92, 3 pls.

Muir, F., and Swezey, O. H. 1916. The Cane Borer Beetle in Hawaii and its Control by Natural Enemies. Bull. 13, pp. 1-51, 4 figs. and 4 pls.

Muir, F., and Giffard, W. M. 1924. Studies in North American Delphacidae. Bull. 15, 53 pp., 6 pls.

In the Proceedings of the Hawaiian Entomological Society

1908. On the stridulating organ of a sphingid from Larat. II, pp. 12-13.
1913. On an abnormal larva of *Lasiorhynchus barbicornis* (Fabr.). II, pp. 219-220.
1913. On some new Fulgoroidea. II, pp. 237-269, pl. 6.
1914. On some Derbidae from Formosa and Japan. III, pp. 42-52.
1914. Presidential address. III, pp. 28-42, 1 diagram.
1914. A Delphacid on bamboo in Formosa. III, p. 53.
1915. New and little known Derbidae. III, pp. 116-136, 3 pls.
1916. Review of the autochthonous genera of Hawaiian Delphacidae. III, pp. 168-221, Part II, biogenetic, pp. 197-221, 79 figs.
1917. New Hawaiian Delphacidae. III, pp. 298-311, 1 pl.
1917. Homopterous notes. III, pp. 311-338, 2 pls.
1918. Two new species of *Nesosydne*. III, pp. 405-407.
1918. Homopterous notes, II. Vol. III, pp. 414-428.

1919. New Hawaiian Delphacidae. IV, pp. 84-108, pls. III and IV, 4 figs.
1919. On the genus *Ilburnia* White (Homoptera, Delphacidae). IV, pp. 48-50.
1921. On some Delphacidae from South India (Homoptera). IV, pp. 480-486, 2 figs.
1921. New Hawaiian Delphacidae (Homoptera). IV, pp. 507-520, 1 pl.
1921. On some Samoan Fulgorids (Homoptera). IV, pp. 564-584, 1 pl.
1922. A new Hawaiian Delphacid (Homoptera). V, pp. 87-88, 2 figs.
1922. An interesting new Derbid Genus (Homoptera). V, pp. 89-90, 5 figs.
1922. New and little known Hawaiian Delphacidae (Homoptera). V, pp. 91-102, 1 pl.
1923. On the classification of the Fulgoroidea (Homoptera). V, pp. 205-247, 5 pls.
1924. New and little known Fulgorids from the West Indies (Homoptera). V, pp. 461-472, 1 pl.
1924. Homoplasmy, or Convergent Development in Evolution (Presidential address). V, pp. 473-483.
1925. On the Status of the Anterior Processes of the Male Genitalia in Homoptera. VI, pp. 41-45.
1926. Some Remarks on Dr. Hem-Singh-Pruthi's Paper on the Morphology of the Male Genitalia in Rhynchota. VI, pp. 323-334, 1 pl.
1926. *Atopocixius*, a New Genus of Uncertain Position in the Fulgoroidea (Hom.). VI, pp. 335-336, 1 pl.
1928. Some remarks on function as a base for classification and its relationship to form. VII, pp. 135-145.
1929. Parallelisms between the Insect Fauna of Hawaii and that of Samoa. VII, pp. 259-260.
1931. New and Little Known Fulgoroidea from South America, (Hom.). VII, pp. 469-479, 1 pl.

Published Outside the Territory of Hawaii

1907. Notes on the stridulating organ and stink-glands of *Tessaratoma papillosa*. Trans. Ent. Soc. London, pp. 256-258, 3 figs.
1909. Notes on the life-history of *Aulacodes simplicialis* Snell. Proc. Ent. Soc. London, XL-XLIV, 4 figs. (A letter to Prof. Poulton).
1912. Two new species of *Ascodipteron*. Bull. Mus. Comp. Zool. Harvard Coll. 54, pp. 349-366, pls. I-III.
1913. On the genus *Lamenia* Stål. Can. Ent., 45, p. 112.
1914. On the original habitat of *Stomoxys calcitrans*. Jour. Econ. Ent. 7, pp. 459-460.
1915. Notes on the ontogeny of the genital tubes in *Coleoptera*. Psyche, 22, pp. 147-152, pl. XII.
1915. A contribution towards the taxonomy of the Delphacidae. Can. Ent. 47, pp. 208-212, etc.
1916. A new Formosan *Purohita* (Delphacidae). Philip. Jour. Sci., 11, D, p. 311.
1916. Additions to the known Philippine Delphacidae. Philip. Jour. Sci., 11, D, pp. 369-385.
1917. The Derbidae of the Philippine Islands. Philip. Jour. Sci., 12, D, pp. 49-104, pl.
1917. A new genus of Derbidae from Borneo. Philip. Jour. Sci., 12, D, pp. 217-218.

1917. A new Philippine genus of Delphacidae. Philip. Jour. Sci., 12, D, pp. 217-218.
1917. The introduction of *Scolia manilae* Ashm. into the Hawaiian Islands. Ann. Ent. Soc. Amer. 10, p. 206-210.
1918. Notes on the ontogeny and morphology of the male genital tube in Coleoptera. Trans. Ent. Soc. London, pp. 223-229, pl. X.
1918. Pipunculidae and Stylopidae in Homoptera. Ent. Mo. Mag. 54, p. 137.
1918. Notes on the Derbidae in the British Museum. Ent. Mo. Mag. 54, pp. 173-177, 202-207.
1918. Notes on the Derbidae in the British Museum Collection II, Derbinae. Ent. Mo. Mag. 54, pp. 228-243.
1919. Some Malayan Delphacidae (Homoptera). Philip. Jour. Sci. 15, pp. 521-531, 1 pl.
1919. Notes on the Delphacidae in the British Museum Collection. Can. Ent., 51, pp. 6-8.
1919. Some new American Delphacidae. Can. Ent., 51, pp. 35-38.
1920. A new genus of Australian Delphacidae. Proc. Linn. Soc. N. S. Wales, 45, pp. 181-182.
1920. The male abdominal segments and aedeagus of *Habrocerus capillaricornis* Grav. (Coleoptera, Staphylinidae), Tr. Ent. Soc. London, 1919-1920, pp. 398-403, pl. XX.
1920. On the mechanism of the male genital tube in Coleoptera. Tr. Ent. Soc. London, 1919-1920, pp. 404-414, pl. XXI
1920. On some African Delphacidae (Homoptera). Bull. Ent. Res., 10, pp. 139-144.
1921. A symbiotic organism in Fulgorids. Psyche, 28, p. 59-60.
1921. On some recent remarks on the phylogeny of Homoptera. Psyche, 28, pp. 116-119.
1921. The male genitalia of *Merope tuber* Newm. (Mecoptera). Tr. Ent. Soc. London, pp. 231-232, 1 pl.
1922. On some Indian Derbidae (Homoptera). Rec. Ind. Mus. Calcutta, 24, pp. 335-342, 8 figs.
1922. New Indian Homoptera. Rec. Ind. Mus. Calcutta, 24, pp. 343-355, 4 figs.
1922. New Malayan Cixiidae (Homoptera). Philip, Jour. Sci. 20, pp. 111-120, 2 pls.
1922. Three new species of Derbidae (Homoptera). Philip. Jour. Sci. 20, pp. 347-349, 4 figs.
1922. A new genus of Australian Cixiidae (Homoptera). Proc. Linn. Soc. N.S.W. 47, pp. 63-64.
1922. On the genus *Elidiptera* Spin. (Homoptera). Can. Ent. 54, p. 61, 2 figs.
1923. On the homology between the genitalia of some species of Diptera and those of *Merope tuber*. Trans. Ent. Soc. London, pp. 176-180, 2 pls.
1923. New species of Fulgorids (Homoptera). Ann. Mag. Nat. Hist. (9), 11, pp. 553-560.
1923. On the characters separating Heteroptera from Homoptera. Ent. Mo. Mag. 59, p. 254.

1923. Two species of Delphacidae (Homoptera) from Kermadec Archipelago. Trans. N. Z. Inst. 54, p. 257.
1923. New species of New Zealand Delphacidae (Homoptera). Trans. N. Z. Inst. 54, pp. 258-259, 4 figs.
1923. A new species of *Derbe* Fabr. (Homoptera) Notulae Ent. Helsingfors, 3, p. 67.
1923. A new Philippine *Stenocranus* (Delphacidae, Homoptera). Philip. Jour. Sci. 22, pp. 157-159, 2 figs.
1923. The genus *Myndus* in the Malay States (Homoptera). Philip. Jour. Sci. 22, pp. 161-170, 1 pl.
1923. Two collections of Fulgoroidea from Sumatra. Philip. Jour. Sci. 22, pp. 171-178, 1 pl.
1923. *Achilixius,* a new genus constituting a new family of the Fulgoroidea (Homoptera). Philip. Jour. Sci. 22, pp. 483-487, 1 pl.
1924. An American Tettigometrid (Homoptera). Ann. Ent. Soc. Amer. 17, pp. 219-222, 6 figs.
1924. Notes on some genera of Derbidae (Homopt.). Proc. Ent. Soc. Wash. 26, pp. 15-19.
1924. A new genus of the family Achilixiidae (Homoptera). Can. Ent. 56, pp. 33-34, 1 fig.
1924. New Malayan species of *Oliarus* Stål, (Cixiidae, Homoptera). Philip. Jour. Sci. 24, pp. 509-527, 2 pls.
1924. On some new and little-known Australian Fulgoroidea (Homoptera). Mem. Queensland Mus. 8, pp. 29-36, 6 figs.
1924. On a new Cixiid attacking coconut palms (Homoptera). Bull. Ent. Res. 14, p. 456, 1 fig.
1925. The male genitalia of *Cupes concolor* Westw. (Coleoptera). Jour. New York Ent. Soc. 32, pp. 167-169, 1 pl.
1925. On the genera of Cixiidae, Meenoplidae and Kinnaridae (Fulgoroidea, Homoptera). Pan-Pacific Ent. 1, pp. 97-110, 156-163.
1925. On the genera *Amblycotis* Stål and *Bostaera* Ball (Delphacidae, Homoptera). Can. Ent. 57, p. 279.
1925. *Parandes,* a new Cixiid genus (Homoptera, Fulgoroidea). Philip. Jour. Sci. 26, pp. 511-512, 2 figs.
1925. The genus *Andes* Stål (Cixiidae, Homoptera). Philip. Jour. Sci. 27, pp. 201-226, 2 pls.
1925. A new species of *Oliarus* from China (Fulgoroidea, Homoptera). Philip. Jour. Sci. 28, pp. 365-366, 1 fig.
1925. On some Fulgorids (Hemiptera-Homoptera) from the Island of Rodrigues. Trans. Ent. Soc. London, 1924-1925, pp. 463-474, 2 pls.
1925. Two new species of exotic Delphacidae (Homoptera). Ent. Mo. Mag. 61, pp. 221-222, 1 fig.
1926. Reconsideration of some points in the morphology of the head of Homoptera. Ann. Ent. Soc. Amer. 19, pp. 67-73, 1 fig.
1926. On some new and little-known Delphacidae from South Africa (Fulgoroidea, Homoptera). Ann. Mag. Nat. Hist. (9), 17, pp. 17-35, 37 figs.
1926. Notes on some African Derbidae (Homoptera). Ann. Mag. Nat. Hist., (9), 18, pp. 227-240, 18 figs.
1926. The morphology of the aedeagus in Delphacidae (Homoptera). Trans. Ent. Soc. London, 74, pp. 377-380, 2 pls.

1927. Insects of Samoa. Fulgoroidea. 2, Hemiptera, London, Br. Mus. (Nat. Hist.), pp. 1-27, 25 figs.
1927. New species of African Meenoplidae (Fulgoroidea, Homoptera). Ann. Mag. Nat. Hist., (9), 19, pp. 197-208, 20 figs.
1927. On some Fulgorids from the south Pacific. Ann. Mag. Nat. Hist., (9), 20, pp. 86-91, 7 figs.
1927. Remarks on the morphology of the male genitalia in Lepidoptera. Ent. Mo. Mag., 63, pp. 172-174.
1928. Notes on some African Derbidae (Homoptera), II. Ann. Mag. Nat. Hist., (10), 1, pp. 498-525, 38 figs.
1928. Spolia Mentawiensia, Fulgoroidea, Homoptera (Cixiidae, Meenoplidae, Delphacidae, Derbidae), Jour. Malayan Br. Asiat. Soc., 4, pp. 392-409, 34 figs.
1928. The evidence for hybrid vigour in insects. Nature, 121, p. 56.
1929. New and little-known South American Delphacidae (Homoptera, Fulgoroidea) in the collection of the British Museum. Ann. Mag. Nat. Hist., (10), 3, pp. 75-85, 22 figs.
1929. New and little-known African Delphacidae (Homoptera, Fulgoroidea) in the collection of the British Museum. Ann. Mag. Nat. Hist., (10), 4, pp. 186-222, 57 figs.
1929. The tentorium of Hemiptera considered from the point of view of the recent work of Snodgrass. Ent. Mo. Mag. 65, pp. 86-88.
1929. The role of function in Taxonomy and its relationship to the genitalia of insects. Trans. 4th. Internat. Congress Ent. Ithaca, Aug. 1928, Tring Herts 2, pp. 600-604.
1930. Three new species of American Cixiidae. Pan-Pacific Ent. 7, pp. 12-14, 4 figs.
1930. IV, New Derbidae from Sierra Leone (Homoptera, Fulgoroidea). Ann. Mag. Nat. Hist., (10), 5, pp. 81-84, 8 figs.
1930. Notes on certain points of morphology of the abdomen and genitalia of Psyllidae. Ann. Mag. Nat. Hist., (10), 5, pp. 545-552, 4 figs.
1931. New and little-known Fulgoroidea in the British Museum. Ann. Mag. Nat. Hist., (10), 7, pp. 297-314; 11 figs.

Co-authorship

1904. Muir, F., and Sharp, D. On the egg-cases and early stages of some Cassididae. Trans. Ent. Soc. London, pp. 1-24, pls. I-V (Coleoptera).
1912. The comparative anatomy of the male genital tube in Coleoptera. Trans. Ent. Soc., London, pp. 477-642, pls. XLII-LXXVIII.
1911. Muir, F., and Kershaw, J. C. On the homologies and mechanism of the mouth-parts of Hemiptera. Psyche, 18, pp. 1-12, 5 pls.
1911. Muir, F., and Kershaw, J. C. On the later embryological stages of the head of *Pristhesancus papuensis* (Reduviidae). Psyche, 18, pp. 75-79, pls. IX and X, (Heteroptera).
1912. Muir, F., and Kershaw, J. C. The development of the mouthparts in the Homoptera, with observations on the embryo of *Siphanta*. Psyche, 19, pp. 77-89, 14 figs.
1907. Kershaw, J. C., and Muir, F. On the egg-cases and early stages of some south China Cassididae. Trans. Ent. Soc. London, pp. 249-252.
1922. Kershaw, J. C., and Muir, F. The genitalia of the Auchenorhynchous Homoptera. Ann. Ent. Soc. Amer. 15, pp. 201-212, 1 pl.