Studies on Culicoides

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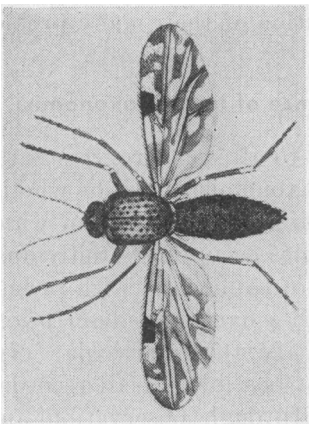

Culicoides furens (Poey)
One of the "no-see-ums"

More than annoying, more than uncomfortable, these irritating insects seriously interfere with human efficiency and comfort and are a potential health menace which merits the attention of public health workers.

BENEFITS from the phenomenal advances made in the control of insects subsequent to the discovery of the insecticidal value of DDT and other chlorinated hydrocarbon insecticides are nowhere more apparent than in the fields of medical entomology and public health. The reduction of malaria in many areas in which the disease was formerly highly endemic and its actual eradication from many others, together with the effective control of epidemic typhus, constitute, of course, the most outstanding examples of these benefits, but there are many others which are well documented in the literature.

Not so long ago it appeared to many that these new chemicals held a final answer to the insect control problem and that we soon should be living in a world free from insect-borne diseases and annoyances. More recently, however, it has been discovered that the new insecticides, although continuing to be of exceedingly great value, are not cure-alls. Many factors, in particular the development of resistance to insecticides in treated populations, operate to emphasize anew a cardinal principle in economic entomology, namely, that to devise the most effective measure for the control of any species, it is necessary to become familiar with the biology of the insect, particularly its physiology and ecology. Thus, although an enormous amount of effort continues to be expended on the chemistry and toxicology of insecticides, entomologists are being forced to devote an increasingly great amount of attention to fundamental studies on the various phases of in-

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sect biology, in order to make effective use of the materials provided and to progress toward the solution of their many problems.

Importance of Insect Taxonomist

Basic to all such progress is the work of the insect taxonomist. It is he who is charged with developing a framework in which each different species occupies its individual niche in the scheme of things and with providing each species with a name and description which serves to identify that particular organism. This makes it possible for all recorded information gained through observation and experiment from whatever source to be cataloged and thus be properly related to the individual species to which it applies. To those unfamiliar with systematic entomology, that field of specialization which deals with the classification of insects, this might appear to be a relatively simple task. However, the number of insect species is immense. The list of described insect species numbers over three-quarters of a million, and others are being added continually. Great numbers of species are superficially similar, although their habits may be extremely diverse. This situation demands that the work of the taxonomist be exceedingly painstaking. The past contains many examples where confusion of species has led to costly errors in control work.

The insects of public health importance in the United States have received an immense amount of attention from taxonomists. With the possible exception of some of the muscoid flies and the mites, keys are available by which most of our disease-carrying or pestiferous insects can be more or less readily identified by trained personnel. From time to time, however, special groups of insects need to be worked over by interested individuals in order that accumulations of newly described species can be incorporated into existing keys or that new and improved keys can be prepared to simplify classification and identification procedure.

Occurrence in Eastern United States

Such a study has been made of the *Culicoides* of the United States east of the continental divide and the results are presented in Public Health Monograph No. 18, published concurrently with this issue of *Public Health Reports*. This monograph includes a complete bibliography, and the sources cited in these comments will be found in that list.

Complementing this work are recent systematic studies made by Wirth on the *Culicoides* of Alaska (1951) and of California (1952). This latter work includes all of the known Pacific coast species.

Thus, information on the current status of this genus of insects in the continental United States, including Alaska, is now available to provide a basis for further work.

In 1949 the known species of *Culicoides* of the world numbered 360 (Vargas 1949a). Ninety-eight of these species occurred in the New World and only 30 of them were listed as occurring in the Nearctic region. This number has been considerably increased by current works which add several new locality records for known species and many descriptions of new species. Eight new species (7 from California and 1 from Alaska) are described in the two papers by Wirth and 4 new species are described by Foote and Pratt. Also, 4 new species and 1 subspecies recently have been described from Oklahoma (Khalaf 1952), which have not been incorporated into the regional works cited. It is certain that others will come to light as a result of the current interest in the genus.

Foote and Pratt discuss 35 species of *Culicoides* in considerable detail. Keys are provided by which adult females may be identified by either colorational or structural characters and by which the males may be identified by characters of the male terminalia. A series of 11 plates giving 126 excellent illustrations serves to facilitate greatly the use of the keys.

A section headed "Notes on the Species" contains references to the important literature of each species, discussions of differentiating characters, biological notes, geographic distribution, and seasonal occurrence. There is a marked paucity of information on the immature stages of *Culicoides* and it is pointed out that further progress in the taxonomy of the genus will require careful study of these forms.

In addition to their taxonomic studies and species notes, Foote and Pratt have provided

general summaries of information on the biology, control, and disease relationships of the genus as a whole. These summaries have served as a basis for the discussion of the genus which follows.

Among the variety of bloodsucking insects which attack man, none can be more annoying in the localities infested by them than certain species of *Culicoides*. They are popularly known as "punkies," "no-see-ums," or "sandflies" and they occur in greater or lesser abundance throughout the tropics and the temperate zones of the world. In medical literature the common name "sandfly" is well established for species of *Phlebotomus*, the transmitters of a virus disease of South America, the Mediterranean region, south China, and India known as sandfly fever, pappataci fever, or phlebotomus fever. The name "sandfly" as applied to *Culicoides*, therefore, perhaps is unfortunate, but there is little likelihood of change since it is the most common name used for these insects in many regions, particularly the South Atlantic and gulf coasts of the United States, where they occur in prodigious numbers.

Culicoides as Disease Vectors

As far as is known, no species of *Culicoides* transmits pathogenic agents in the United States or in Canada. In some other parts of the world, however, several species have been incriminated as intermediate hosts of certain filarial worms which infect man, and also as vectors of some virus diseases of domestic animals. Of chief interest among the species which are intermediate hosts of filarias which infect man are *Culicoides furens* (Poey) and *Culicoides paraensis* (Goeldi), the transmitters of *Mansonella ozzardi* in parts of South and Central America; and *Culicoides austeni* Carter, Ingram, and Macfie and *Culicoides grahami* Austen, the transmitters of *Acanthocheilonema perstans* (Manson) in Africa. *C. grahami* also is credited with transmitting *Dipetalonema streptocerca* (Macfie and Corson), a microfilaria which coexists with *A. perstans*. Large percentages of the human population in infected areas harbor these related filarial parasites. However, they usually produce no pronounced clinical manifestations and their importance is not established. Observations in Mexico have indicated that *Culicoides filariferus* Hoffman may transmit *Onchocerca volvulus* (Leuckart), which causes blinding filariasis. Gnats of the genus *Simulium* are the usual vectors of this organism and it may be that the filariae observed in *C. filariferus* were bovine parasites.

Culicoides nubeculosus (Meigen) and *Culicoides parroti* Kieffer transmit *Onchocerca cer-*

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The accompanying article discusses the principal findings presented in Public Health Monograph No. 18, published concurrently with this issue of Public Health Reports. At the time the monograph was prepared, both authors were with the Communicable Disease Center, Public Health Service, Atlanta, Ga. The senior author, an officer in the Reserve Corps of the Public Health Service, has since been assigned to the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

Readers wishing the data in full may purchase copies of the monograph from the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C. A limited number of free copies are available to official agencies and others directly concerned on specific request to the Public Inquiries Branch of the Public Health Service. Copies will be found also in the libraries of professional schools and the major universities, and in selected public libraries.

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Foote, Richard H., and Pratt, Harry D.: The Culicoides of the eastern United States. Public Health Monograph No. 18 (Public Health Service Publication No. 296). 56 pages. 11 plates (126 figures). U. S. Government Printing Office, Washington, 1953. Price 40 cents.

vicalis Railliett and Henry, the cause of fistulous withers and poll evil in horses in England (Steward 1933). *Culicoides pungens* de Meijere and other *Culicoides* species are reported to be vectors of *Onchocerca gibsoni* (Cleland and Johnson), a filaria which infects cattle in the Federated Malay States. The worms cause large nodules to form on the brisket and flanks, and large losses result from injuries to hides and carcasses (Buckley 1938).

In addition to being the intermediate hosts of filarial worms of which man and animals are definitive hosts, it has been shown that *Culicoides* may transmit the virus which causes fowlpox of chickens and turkeys (Tokunaga 1937) and the virus which causes bluetongue of sheep (Du Toit 1944). Fowlpox is a common and widespread disease of poultry in the United States and, although *Culicoides* is not known to be a vector here, other biting flies, including several of our mosquitoes as well as the stable-fly, *Stomoxys calcitrans*, have been incriminated as transmitters. Of particular interest at this time is information that bluetongue of sheep has become established in California and may be present in other western States as well. Previously the disease, which also may affect cattle, was not known outside Africa. In California the infections become apparent during the fall when sheep are moved from mountain pastures to the Central Valley where *Culicoides* and other biting flies are known to be abundant. As yet no reports of studies to determine the vectors of the disease in this country are available. Because of the importance of bluetongue, an act was passed by the 83d Congress on August 8, 1953, which added this disease to those animal infections which the Secretary of Agriculture, either independently or in cooperation with States, other political subdivisions, and individuals, is authorized to "control and eradicate" (James H. Steele, personal communication).

As has been mentioned, *Culicoides* may be of primary concern in the areas where they abound solely on account of the extreme annoyance caused by their bites. Reports of such ravages are common. One of unusual interest occurred during the recent war when the attacks of the Palau gnat, *Culicoides peleliouensis* Tokunaga, on troops stationed in Peleliu, Western Caroline Islands, were so severe that not only was the efficiency of the men greatly reduced due to irritation and lack of sleep but in many cases scratching of the bites resulted in secondary infections which made hospitalization necessary (Dorsey 1947).

In the United States *Culicoides* have been notorious pests from early times, rivaling mosquitoes in their ability to make life so unbearable at certain seasons that the development of otherwise salubrious areas has been greatly retarded. Such areas are not difficult to locate along the coast of the southeastern United States, where large expanses of salt marshes provide favorable breeding grounds for *Culicoides canithorax* Hoffman, *Culicoides melleus* (Coquillet) and *C. furens* (Poey). These probably are the most important economic species in this country.

The larvae of *Culicoides* normally are aquatic, but those of some species are known to survive for several days in moist situations with no free water present, while others appear to be adapted to a life in moist soil or vegetable debris. Depending on the species, they are to be found in mud, sand, and debris at the margins of both salt- and fresh-water ponds, springs, lakes, streams, marshes, and swamps, and also in tree-holes, the slime-covered bark of trees, and manure pits. They are minute, white, free-swimming, eel-like creatures without legs of any sort. The larger species rarely exceed 9 mm. in length. They have biting mouth parts and have been observed feeding on decaying vegetation and on protozoa, algae, and other micro-organisms; some are reported to be carnivorous and cannibalistic. The larval stages of the salt-marsh species referred to in the preceding paragraph are said to last from 6 months to 1 year. When mature, pupation occurs, and the adults emerge in from 3 to 7 days. Observations indicate a life of some 10 days for the adult and that 3 or 4 blood meals are required prior to oviposition. The eggs are cigar- or banana-shaped and are deposited in masses of up to 30 in shady spots in the breeding places.

Biting Habits

Adult *Culicoides* are small flies, about 1 to 2 mm. in length and usually are gray in color.

One of the more apparent characters which distinguishes most species of *Culicoides* from their near relatives is the presence of cloudy spots and areas on the wings. As with mosquitoes, only the females are biting pests, the mouth parts of the males being unsuited for sucking blood. Biting habits vary considerably among the different species. In general, they are quite aggressive. They will crawl into the hair and under loose clothing to bite and will attack all exposed body surfaces. One who has not personally experienced an attack of these insects when they occur in such abundance as to resemble clouds can hardly appreciate the suffering they can cause. The bites of different species vary in severity and there also is variation in individual sensitivity to the bites of the same species. When only a few sandflies are around they frequently are felt before they are seen, which accounts for their "no-see-ums" appellation. The bites themselves are not painful, giving only slight pricking sensations. Later, wheals form at the sites of the lesions, and burning and itching may persist for several days. Some persons living in infested areas acquire a certain degree of immunity to the bites, but this is by no means a common phenomenon.

Sandflies bite at all hours of the day or night although their attacks appear to be most severe in the twilight hours. They are attracted to lights at night. Their activity is greatest during warm periods when there is little or no air movement. Observations in Alaska indicate that *Culicoides* were unable to fly in winds of 3.5 miles per hour and that adult activity dropped abruptly at temperatures below 55° F. (Travis 1949).

Control

Early efforts to obtain relief from sandflies in infested areas included the use of smudges, repellents, and screens—measures which still retain their usefulness. However, smudges largely have been replaced by insecticidal fogs; old-time repellent concoctions of citronella, pennyroyal, and other aromatic oils have been succeeded by more effective modern preparations; and mosquito screens now are painted with DDT solutions or with mixtures of pyrethrum extract concentrate in lubricating oil to exclude sandflies from dwellings, thus eliminating the need for covering windows with fine muslin cloth, which shuts out air as well as sandflies. To the modern approaches also must be added the application of residual insecticides.

Of particular interest among control attempts was the work carried out to relieve annoyance from *Culicoides* during the inaugural meeting of the International Monetary Conference held March 8–22, 1946, at a resort hotel near Savannah, Ga. (Bruce and Blakeslee 1948). The report of this work has been summarized in the monograph as follows: "Residual applications of DDT, in conjunction with airplane spraying and thermal aerosols, were considered to be of most value. An oil solution of 5-percent DDT was applied, by mopping, to all window and door screens and to screen hoods fitted to all outdoor lights. A kerosene emulsion containing 2.5-percent DDT was applied to the garage, the kennels, and the understructure of the boathouse. A water suspension containing 1-percent DDT was sprayed to a height of about 12 feet on the walls of the hotel, the servants' quarters, and the surrounding shrubbery. The walled front of the swimming pool terrace and a balustrade around the pool were sprayed with a 2.5-percent DDT emulsion. These residual treatments, together with a subsequent regular spraying over the entire property with 5-percent DDT, reduced the biting incidence of *Culicoides* species in this vicinity nearly to zero. These authors also reported that thermal aerosols were fairly useful for emergency treatments when the sandflies were present in large numbers on the grounds. However, they considered this method of control to be of secondary importance to residual spraying or painting."

Reports of interest concerning the successful use of insecticidal fogs alone against *Culicoides* adults include a demonstration at a resort area in New York State (Glasgow and Collins 1946). A 5-percent DDT solution in kerosene was dispersed by a truck-mounted thermal aerosol generator at the rate of 0.2 pound of DDT per acre. Relief was immediate and lasted for 3 days. In a demonstration against *Culicoides* in Florida (Madden et al. 1946), a 200-acre swamp was

treated with a 5-percent DDT solution, by airplane, at the rate of 2 quarts per acre, which prevented sandfly annoyance for a 4-day period. Other reports are not so favorable, however. One of these concerns attempts to prevent attacks by *Culicoides* in Alaska by the use of heat-generated DDT aerosols. Here only temporary relief from annoyance was obtained; the flies infiltrated the control area immediately after disappearance of the fog (Travis 1949).

During and subsequent to World War II, an immense amount of work was directed toward developing repellents for use against insect transmitters of diseases. None of these has been recommended as highly effective against sandflies. However, progress has been made. Protection against *Culicoides* in Alaska for periods ranging from 42 to 49 minutes was obtained by the use of dimethylphthlate and a mixture of Indalone, "Rutgers 612," and dimethylphthlate in proportions of 6, 2, and 2 parts, respectively (Travis 1949). Another material, "B 800," a butoxy-propylene compound, is reported to repel sandflies for from 2 to 6 hours (Granett et al. 1949).

Reduction of Infested Areas

As in the case of mosquitoes, the most desirable approach to the control of sandflies in populated areas is by measures directed against their breeding places to prevent emergence of the adults. Early studies on this approach in the southeastern United States, principally at Savannah, Ga., and in St. Lucie County, Fla., were participated in by several workers (Dove and Hall 1934; Dove et al. 1932; Hull et al. 1934, 1939, and 1943). In general, it was found that salt-marsh sandfly breeding was concentrated in the soil of the wet, shaded portions of marshes and in ditches and other depressions which remain moist. On marshes which had been ditched for mosquito control, 90 percent or more of the sandfly larvae were concentrated within 10 feet of the ditch banks. Although some reduction in these populations may have resulted from the mosquito control drainage, it apparently was not sufficient to be reflected in any appreciable relief from sandfly attacks in nearby urban areas. Even with sandfly larvae thus concentrated along the ditches, the cost of applying larvicides to increase the degree of control would have been prohibitive. Consideration was given, therefore, to ways for reducing the infested area. Based on the observation that sandfly larvae did not pupate and emerge in areas which were flooded continuously, an experimental marsh was diked and an attempt made to keep it covered with water. By the creation of such an artificial lake it was hoped to restrict sandfly breeding to its margins, where larviciding would be practical. Although theoretically feasible, this method was abandoned because of the impossibility of maintaining the entire marsh continuously flooded. The next approach was an attempt to dry up an entire marsh of 1,000 acres in extent by the construction of dikes to exclude tidewater and the installation and use of pumps and automatic tide gates to remove rainwater. Records indicate this method was feasible and effective. Sandfly emergence was reduced up to 90 percent as compared to emergence in uncontrolled areas. Satisfactory mosquito control likewise resulted, and effective control in the area was continued by the local mosquito control district for several years (Platts et al. 1943).

Although considerable interest in diking and pumping work was manifest in sandfly-infested communities prior to World War II, the method has not become widely used. The expense of the necessary installations is, of course, considerable—prohibitive in many communities which are surrounded by immense marsh areas. Also, the advent of the newer insecticides undoubtedly served to restrict diking and pumping projects. The use of these insecticides against adult sandflies already has been mentioned. As larvicides, they likewise have shown great promise. The following examples may be cited:

On Peleliu Island in the southwest Pacific *C. pelelioensis* was effectively controlled by treating large breeding areas with 10-percent DDT dust at the rate of 12 to 15 pounds per acre. A 3-percent DDT-triton-xylene emulsion at the rate of 3 gallons per acre also was effective, but coverage was more difficult to obtain (Dorsey 1947). In England tests were made with a solution of 5 percent of the gamma isomer of benzene hexachloride in miscible oil at a dilution of 1 part to 500 parts water against

the larvae of *Culicoides obsoletus* (Meigen) and *Culicoides impunctatus* Goetghebuer. The solution was applied so as to give a deposit of 100 mg. per square foot. Heavy rains subsequent to application increased penetration. It was concluded that the spraying of breeding grounds with this material prior to the expected emergence of a brood would provide effective control (Hill and Roberts 1947).

In the United States comprehensive tests with a number of sandfly larvicides are being carried on cooperatively by the Florida State Board of Health, the U. S. Department of Agriculture, and several Florida mosquito control districts. In small-plot tests chlordane and heptochlor gave excellent control of larvae when applied at the rate of 0.25 pound per acre, while dieldrin, aldrin, and gamma benzene hexachloride gave similar results at 0.5 pound per acre. In practical tests, when used at the rate of from 1 to 2 pounds per acre, these materials prevented breeding in marshes for long periods. DDT at 2 and 4 pounds per acre and toxaphene at 2 pounds per acre gave poor immediate control and rather erratic results thereafter. Greatest residual toxicity was indicated for dieldrin—65 weeks when applied at 2 pounds per acre (Goulding et al. 1952).

From THE CHILD . . . . .

Interagency Help for Migrants

The story of the achievements of the Rural Health and Education Committee in Fresno County, Calif., in alleviating the hardships among migrant workers in the lower half of the San Joaquin Valley is related by Mrs. I. H. Teilman (November 1953). On the west side of the county are great cotton ranches employing 10,000 migrant workers during peak crops. Most families live in isolated camps as semipermanent residents remote from the county's hospital, medical care services, and the established health and social agencies.

The nucleus of the interagency group was formed 3 years ago when the desperate situation of the seasonally unemployed migrants called for emergency measures. It was obvious that more could be accomplished by dovetailing the efforts of existing services than by the individual agencies working alone. Two of the most urgent needs were for health centers near the camps and care of the children while their mothers worked.

A health and welfare project was planned for the distressed families; a small committee which later became the Rural Health and Education Committee was organized; and the Rosenberg Foundation granted $22,000 in 1951.

The 60-member committee today includes representation from the official health, social welfare, education, and employment agencies—from such groups as the Fresno State College, the State Youth Authority, the Red Cross, the County Medical Society, the National Council of Churches, and the Agricultural Extension Service. Other members include clergymen, businessmen, wives of agricultural laborers, and growers. One of the growers serves as chairman—a sign that the employers are alert to the community's needs and active in its efforts. Mrs. Teilman is vice chairman.

"The Committee realizes that its work so far is only the proverbial drop in the bucket," Mrs. Teilman says, but the achievements she recounts are impressive—clinics (general, medical, prenatal, and well-baby), a child-care center for children over 2, a full-time adviser in homemaking, classes in home nursing, recreational activities, and parent education.

The Child has been changed in name to *Children* and is issued bimonthly beginning with the January–February 1954 issue. The new subscription rate is $1.25 a year ($1.75 for foreign mailing). Single copies are 25 cents each. The publication is issued by the Children's Bureau, U. S. Department of Health, Education, and Welfare.
