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PROTECTION FROM NORTHERN BITING FLIES

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INTRODUCTION

A great deal has been published on the use of repellents against biting, and especially disease-transmitting insects. Rather less has been written on the use of protective clothing. The general subject of the protection of the individual, whether human or animal, has received but little attention.

In malaria control, this problem is one of the absolute prevention of biting. In relation to northern species of biting flies, which are principally of importance on account of the more direct effects of their attentions, the approach is different. The absolute prevention of biting, even if it were possible, is unnecessary and perhaps even undesirable. The general nature of the northern biting fly problem has been reviewed by West (1951) and by Twinn (1952). The only presently available alternative solution to the mosquito and blackfly problem is the direct use of insecticides. For the tabanids there seems to be no alternative. There are no immediate prospects of ecological or biological controls for any of the three important groups. The use of insecticides is less promising against northern species than against *Anopheles,* largely because of their much greater dispersal power. Treatment of areas in proportion to the square of this range of dispersion is necessary if lasting relief is to be obtained, and travel and transportation over these areas are also more difficult. The methods of personal protection are thus practically promising as well as being ethically attractive.

THE FACTORS WHICH ATTRACT BITING FLIES

No scientific approach to the problem of personal protection from biting flies is possible without an understanding both of the factors which attract these insects to their hosts, and those which stimulate them to feed. This understanding has only recently been much sought after, and, although important contributions have recently been made by Brown *et al.* (1951), Sarkaria and Brown (1951), Peterson and Brown (1951) and Brown (1951), it is still far from complete. It is itself dependent on a knowledge of the sensory physiology of the insect in question, which also, in spite of recent contributions (Roth, 1951), is still inadequate. Some of the more important information on this subject is summarized in Table 1. Scientific methods of personal protection must be directed at interfering with this mechanism of attraction and stimulation, and when this interference fails, at mitigating the resulting effects.

THE EFFECTS OF BITING FLIES ON MAN AND ANIMALS

Direct effects

There are many reports, not all of them authentic, of men and animals being killed by northern biting flies. Current methods can protect men entirely against such occurrences without an excessive expenditure of time or materials. There remain, however, very considerable discomforts and delays, risks of secondary infections, and sometimes reactions to the bites which may require hospital treatment. In a really intense blackfly and mosquito population, conversation and even breathing become difficult unless one is prepared to swallow or inhale many of the insects. The effects of biting flies on

TABLE 1. Factors which may influence the attraction and feeding of northern biting flies.

Sense and Stimulus	*Groups of flies in which operative*	*Authorities*
Chemical Senses		
Moisture	Mosquitoes	(van Thiel, 1939 (deLong *et al.*, 1946 (Brown, 1951 (Brown *et al.*, 1951
Carbon dioxide	Mosquitoes	(Rudolfs, 1922 (Brown, 1951 (Brown *et al.*, 1951
	Blackflies	(Dalmat, 1950
Smell	Mosquitoes	(Rudolfs, 1922 (Mer *et al.*, 1945 (DeLong *et al.*, 1946 (Brown, 1951 (Brown *et al.*, 1951 (Sarkaria & Brown, 1951
Taste	No studies known	
Visual sense		
Colour	Mosquitoes	(Nuttall & Shipley, 1901–3 (Gjullin, 1947 (Brown, 1951
	Blackflies	(Davies, 1951
	Tabanids	Portchinsky, 1915
Movement	Tabanids	(Stone, 1930 (Twinn *et al.*, 1948
	Mosquitoes	(Kennedy, 1939 (Haddow *et al.*, 1947
Mechanical Senses		
Surface texture	Mosquitoes	Brown, 1951
Thermal Sense		
Radiation	Mosquitoes	Peterson & Brown, 1951
Temp. gradient	Mosquitoes	(Howlett, 1910 (Marchand, 1920 (deLong *et al.*, 1946 (Brown, 1951 (Peterson & Brown, 1951

man and animals may be divided into physiological and psychological effects, although there is some overlap.

The simplest physiological effect of biting fly attack is the loss of blood; a calculation on this is of interest. The most intense conditions of mosquito attack studied in northern Canada to date were such that a man would receive about 280 bites on the forearm from wrist to elbow, on exposing this for one minute. The total skin surface is about 33 times that of the forearm, so that a completely unprotected man—and many fabrics used for summer clothing give very little protection—could receive a maximum of 9250 bites per minute. The average weight of a blood meal is not less than 2.5 mgms., so that the blood loss would be at least 23.1 gms. per minute. At this rate a man would lose half his blood, which would probably prove fatal, in about 1¾ hours. Blackflies and tabanids may be present at the same time, and although the biting rates for these are usually much lower, the loss of blood from their larger punctures, in which an anticoagulin is present, would be considerable. Fortunately the conditions necessary for such intense attack are rare and of short duration.

The reaction to bites

With reference to the reaction to mosquito bites, Macloskie (1888) regarded the middle lobe of the salivary gland as the source of the poison concerned. Schaudinn (1904) and Roy (1927) demonstrated somewhat inconclusively that the reaction is due to an enzyme produced by constant commensal fungi or yeasts, living in the oesophageal diverticula. The results of Cornwall and Patton (1914) seem to support this view, and Hindle (1914, p. 68) quotes other work in support of it, and states that the fungus, one of the Entomophthoraceae, is transmitted through egg, larva, and pupa. Bruck (1911) however, extracted a toxin which he named *culicin* from the bodies of mosquitoes and assumed this came from the salivary glands, and McKinley (1929) has convincingly demonstrated the presence of a poison in the salivary glands of *Aedes aegypti*. Hecht (1927) also supports this view, explaining Schaudinn's results as a general effect, produced by any mosquito tissue. None of this work relates to northern species of *Aedes*.

The toxic effects of blackfly bites are much more serious than those of mosquitoes but have been less studied. Stokes (1914) was able to reproduce the characteristic lesions by hypodermic injection of various extracts of the head and thorax. Patton and Evans (1929, pp. 140–150) suggest a toxic enzyme in the saliva as the irritant. The reduction in the reaction shown by an individual as the season advances has been generally regarded as attributable to the development of immunity; it could equally well be due to physiological differences in the later generations of the insect. Observations on the reactions to the bites of tabanids are very few, but the reaction may certainly be quite serious (Miller, 1951).

More recently, the allergic nature of the reactions to arthropod bites generally has been realized (de Meillon 1949, Heilesen 1949, Gordon and Crewe, 1948, 1950) with a resultant reduced interest in the origin of the toxic material.

Disease transmission

None of the northern species of biting flies is known to serve as a true vector for any disease or parasite of man in northern areas. The possibility of mechanical transmission of disease is also remote at present, in view of the shortness of the season, the very sparse human population, and the resulting improbability of any individual insect taking blood meals from two humans. Perhaps some encephalitides may prove to be of importance. Diseases of this group are believed to be largely transmitted by *Culex tarsalis* Coq. in Washington (Hammon *et al.*, 1942), and probably in Saskatchewan (Rempel *et al.*, 1946), while in southern Manitoba the virus has been recovered from *Culex restuans* (Theo.) Norris, 1946). Elsewhere, species of *Aedes* are vectors of these diseases, and Madsen *et al.* (1936)

have shown laboratory transmission by *A. dorsalis* (Meig.) and by *A. nigromaculis* Ludl., the latter species recorded from Churchill, Manitoba, by McClure (1943) in 1936 but not found there since.

Transmission from animal reservoirs must be regarded as less unlikely, and transmission of animal diseases is perhaps common. *Simulium venustum* Say transmits an important disease of ducks caused by *Leucocytozoon anatis* Wickware closely related to the malaria plasmodia (O'Roke, 1930). Scott (1920) has shown that *Hybomitra septentrionalis* Loew is capable of transmitting swamp fever or infectious anaemia of horses, and various workers (Roubaud & Colas-Belcour 1937, Yen 1938) have demonstrated the ability of the filarial parasite of dogs *Dirofilaria immitis* Leidy to develop in *Aedes cinereus* Meig., *A. punctor* Kirby, and possibly *A. flavescens* Müll., and *A. excrucians* Wlk. Tularaemia and *Plasmodium gallinaceum* have also been transmitted experimentally by *H. septentrionalis* (Parker, 1933) and *A. cinereus* (Olin, 1942), and by *A. campestris* D. & K. (Cantrell & Jordan, 1945) respectively.

Psychological effects

The psychological effects of biting fly attack may be no less serious than the physiological effects. These effects result partly from the stinging sensation of the insect mouthparts, partly from the manual *removal reaction* to this, and partly from the continual noise and the impact of insects on the face and person. The tabanids and the mosquitoes are much more important in connection with these effects than are the blackflies. Initially, it requires the bite of an insect to evoke the removal reaction; as the severity and duration of exposure are increased it is soon evoked by insects alighting on the skin, and finally in many individuals by non-existent insects, the hallucination of an insect biting being unquestionable.

Psychological effects can rapidly cause a serious reduction of individual efficiency, and a still more serious lowering of group morale. Under very intense attack most individuals would become ineffective far sooner from psychological than from direct physiological causes. The rapidity with which a susceptible person can become worked up into an emotional state bordering on dementia, as a result of the continually accelerated and increasingly ineffective removal reactions, has to be seen to be believed.

A stage beyond excessive use of the removal reaction is that of running away, a normal reaction on the part of many animals to the attentions of flies. While temporary freedom from mosquitoes and blackflies can sometimes be obtained by running into the wind, this is a most effective method of assembling a large population of tabanids. The direction of caribou migration may well be in part determined by that of prevailing winds during the mosquito season (Seton, 1912, pp. 209, 257).

External Protective Devices

Smudge Fires

One of the oldest, and still a widely used protective device is the smudge fire. Among the best ingredients for such a fire is damp moss, fortunately a usual feature in the flora of biting fly infested areas. A strong wood fire is established first and thereafter a nice balance is maintained between wood and moss. Such a fire in the doorway of a cabin, although less effective, is cheaper and not very much more inconvenient than screening. The protection of a series of such fires will be actively sought by livestock when flies are bad. Medical authorities disagree regarding the long term effects of the smoke on man and livestock.

Repellents

While great improvements have been made in materials for application to the skin or clothing for protection against biting flies, these have been almost entirely the result of empirical testing, mostly against *Anopheles* and *Aedes aegypti*, of a very large number of permissible materials (Linduska & Morton, 1947, Travis *et al.*, 1949). These materials have been found to show similar effectiveness against northern species (Applewhite & Smith 1950, De Foliart 1951, Travis & Smith 1951), although the failure of 2 phenyl-cyclohexanol against blackflies is an exception. It seems unlikely that further significant advances can be made without a more fundamental approach on the lines already indicated. The superiority of most of the more recently discovered materials over the now established dimethyl phthalate and ethyl hexanediol can only be demonstrated by careful tests, and is not of great practical significance. Plasticising properties and irritant effects are shown by so many of these materials that they would almost seem to be a *sine qua non* of repellency. These properties, and the still rather ephemeral nature of the protection given under severe conditions, are the principal difficulties. Rubzov (1939), however, has claimed that cinnamon oil remains effective against blackflies for 24 hours. Most recently developed materials, inasmuch as they show little action at a distance, and must be applied as a complete if tenuous film, appear to act through the gustatory rather than the olfactory senses of the insect. This difference from some of the older materials is not always appreciated by the user, who may thus fail to get full advantage of their superior properties. Gustatory repellents of course have potentially greater persistence.

Problems also exist in the formulation and dispensing of these materials; there is much to be said for a solid or semi-solid preparation (Cameron 1946, 1948), which may avoid the need for a bulky container, and the risk of spilling. If a liquid form is preferred a glass bottle, in spite of its wide use, is probably the least suitable container. A metal oil can type of container with a small spout fitted with a screw cap is very suitable. Bulk dispensers of the type employed for liquid soap, mounted at the exits from tents and buildings have proved very useful (Myler, *in litt.* 1947).

Protective clothing

One of the methods by which greater persistence has been sought with some success, is impregnation into normal, or partially protective clothing. Fully protective clothing, however, is the only escape from repeated applications of repellent which is at present possible. In the design of protective clothing there is a threefold problem. Of the three important groups of northern biting flies, the tabanids usually bite only the exposed portions of the body, the blackflies bite the exposed portions and by preference, perhaps, underneath the clothing especially where its constant proximity to the skin facilitates their penetrating this, and the mosquitoes attempt to bite almost indiscriminately on exposed areas and through the clothing, but rarely underneath this. It is necessary then, first, to reduce exposed area to the minimum consistent with comfort and function; secondly, to prevent access by blackflies to the space between it and the body; and thirdly, to prevent mosquito penetration through the clothing to the skin. For most activities in fly country the face, often including the ears, and the hands, must be exposed much of the time. Temporary protection may be afforded to these areas by head nets and gloves. Exposure of the arms to the elbow may be necessary, when arm nets may be worn.

It must be recognized that all types of head net, from ½″ mesh treated with repellent to those fine enough to exclude blackflies without repellent, say 20 mesh, no matter how fine the threads, definitely impair vision. This is particularly true for such activities as shooting. The great majority of them also offer a considerable obstacle to eating, smoking and recognition. Insects which get inside a head net, are as effectively prevented from getting out again as others are from getting in. In traveling through forest or heavy bush country, there is only one item of clothing more likely to be either torn or removed from the wearer than a head net, and that is the arm net.

A form of protection for the head, which is nearly as effective, especially against tabanids and mosquitoes, yet which gets away from all of these drawbacks, has been developed. This consists of a stitched cotton cloth hat with a 3″ brim all round, actually an Indian Army jungle hat, to which a shoulder length fringe of strings is attached at the edge of the brim, with the exception of a space of 5″ at the front. The strings are of cotton, 10″ long and ¼″ apart. This hat has been tried by many people during the last two fly seasons and has been favorably reported on. The idea was developed from a combination of the fly fringe used to protect draught animals in the tropics, and the oil soaked rag placed under the back of the hat and reaching to the shoulders, used by workers on the Hudson Bay Railway. If desired, the fringe may be extended across the front down to eye level, or even full length; vision still remains better than through a net. There is only one item of clothing instead of two; since most head nets require to be worn with a hat. If the fringe is soaked in repellent, the degree of protection is increased. If the wearer of such a hat is attacked in spite of it, a single flick of the head will do duty for several rather elaborate removal reactions.

Entry of blackflies to the space under the clothing is principally via the wrists, neck, and the front openings of shirt and trousers; socks, rubber boots, or puttees worn over the ends of the trousers effectively seal this entry. Although protection may be obtained with double fly closures, undoubtedly the most satisfactory arrangement for the front of the shirt and trousers is the zipper fastener. If the zipper closing the shirt extends fully up to the neck, and this is reasonably closely fitted, this, in conjunction with head net or fringed hat will protect the neck region. Entry at the wrists may be prevented by either a moderately close fit and a band of pile lining, or by a still closer fit alone; a full, sewn in, gusset is essential with either method. Neither is entirely comfortable.

There are two methods by which mosquitoes may be prevented from reaching the skin through the clothing. The first is to use a fabric of such close weave that the proboscis cannot penetrate (Annand, 1945a), that is, with a maximum aperture between threads less than about 0.08 mm. The stylets themselves will pass through holes very much smaller than this, but, with fabric of cotton and synthetic fibres at least, it seems necessary for the tip of the labium to make contact with the skin (Christophers, 1947). While such materials exist (Annand *et al.*, 1945a, b), they are inclined to be expensive and too warm; they may however have other desirable properties, such as wet resistance. The second method is to use a material with a porous, or even a cellular weave, held away from the skin by a partial or complete lining of netting or other material with sufficient thickness to prevent the proboscis of the mosquito from reaching the skin (Annand, 1945b). It would be expected that the combined thickness of the two materials should not be less than the length of the longest proboscides—that is, about 4.0 mm.; in practice however it seems possible to obtain complete protection with a total thickness considerably less than this, perhaps as little as 2 mm. A string vest worn under a cellular cotton shirt gives complete protection and is cool and comfortable in the warmest weather. The lining may be limited to areas such as the back and shoulders where the shirt is in constant close contact with the body. Any clothing which gives inadequate protection may be improved by impregnation with repellents, which is a promising approach to the problem (Smith & Cole, 1951), or by casual application of these to it. These matters have been fully discussed by Christophers (1947).

Because of the now well established fact that more mosquitoes will land on dark coloured than on similar light coloured fabrics it has been recommended that clothing should be light in colour. Inasmuch as large numbers of insects on the clothing may have psychological effects this recommendation is justified, particularly if fully protective clothing, gloves and head net, are worn. As Hadaway (1951) has pointed out, however, it may well be that flies are driven off light coloured clothing, onto adjoining areas of exposed skin; if this is so, darker colours would be preferable. There is some suggestion that mosquitoes, like the honey bee, will attack more readily through materials of animal origin. Jones (*In Litt.* 1951) has suggested that this may simply be due to differences in moisture content. Commonly such materials are rougher in texture, and this in itself facilitates mosquito activity on them; here too, of course, clothing of more attractive material might well mean less insects on the exposed skin.

Fly proof buildings

Inside buildings, the mosquitoes are much the most important group of northern biting flies. Biting by either tabanids or blackflies indoors is rare except in unusually well illuminated situations such as white tents and sun porches. The provision of darkened shelter for livestock as a protection against these two groups is a well established procedure. However, although they do not bite there, both tabanids and blackflies may be attracted into tents and buildings in very large numbers, and their exclusion is desirable on other grounds.

There are two principles involved in the exclusion of flies from buildings, first, the screening of all openings, including ventilators, drainpipes, and sometimes chimneys, with suitable mesh wire or plastic screening; secondly, the use of double doors at all entrances, preferably combined with a ready means of disinfecting the space between them, as with a pyrethrum aerosol dispenser.

Little has been published on the subject of the mesh size of screening required to exclude various groups of flies. Davey and Gordon (1938), found the mesh size in use in West Africa too large to exclude all *Anopheles gambiae* Giles and *Anopheles funestus* Giles, and recommended 16 x 16 meshes to the inch and 28 S.W.G. wire. It is, of course, necessary to specify either the opening size, or the number of meshes to the inch and the gauge of the wire. There appear to be no published data with regard to the exclusion of blackflies, accordingly figures obtained by L. R. Pickering, Division of Entomology, Department of Agriculture, Ottawa, are given here in Table 2. On the basis of these, 20 mesh screening of 28 S.W.G. wire should be adequate for blackflies. According to Davey & Gordon it is the dorso-ventral dimension of the mesothorax which is important; the smallest value of this dimension found in 50 specimens of *S. venustum* was 0.0378 in., which is in accordance with the figures in Table 2. A number of specimens of common biting species of *Culicoides* were also measured, and the mesothorax of the smallest of these was 0.0169 in. deep. On this basis 40 mesh screening of 34 S.W.G. wire should exclude *Culicoides;* plastic screening is available in meshes considerably finer than this, and the cost is not prohibitive.

Self-closing devices on all entrance doors are useful. Outside privies hardly justify the application of the double door, but the lighting is usually so bad that biting is not serious even by mosquitoes. In more temporary camps some arrangement of portable screening for latrine accommodation is most desirable. A general purpose fly shelter is also of great value in maintaining the morale of men in camp

TABLE 2.—The penetration of blackflies through mesh of various sizes. Churchill, 1951.

No. of meshes per inch	Diameter of wire or filament, ins.	Dimensions of openings, ins.	Penetration
18 x 14	0.0110	0.0603 x 0.0445	10/30
19 x 16	0.0150	0.0475 x 0.0377	2/30
20 x 20	0.0110	0.039 x 0.039	2/30
20 x 20	0.0154	0.0346 x 0.0346	0/30
24 x 24	0.0104	0.0312 x 0.0312	0/30

under bad fly conditions. In forest country such a shelter can be readily and cheaply constructed with cheesecloth and staples and will remain serviceable for a full season. In tents, as in buildings, adequate screening and double doors are desirable.

When buildings and tents become invaded by flies, a hand spray pump, or an aerosol bomb is the best instrument for disinfestation. The aerosol bomb is the more convenient and the more expensive, it has the drawback of being useless once it is empty, even if abundant insecticide is at hand. There are still plenty of extremely badly designed hand spray pumps on the market, but a good one is as efficient as an aerosol bomb and much cheaper in use. For general purposes a pyrethrum DDT preparation is probably as good as anything. Needless to say the DDT must be omitted for use in any structure in which biological work with insects may be contemplated.

When, in spite of all methods of protection, the irritation of bites received begins to interfere with sleep, some treatment is called for. Any application for this purpose should have antiseptic properties to guard against secondary infection. Ammonia, washing soda, iodine, and more recently various ointments containing local anaesthetics are in common use. A preparation of this type recommended by Kingscote (In *litt.* 1951) is as follows: benzocaine 10%, salicylic acid 5%, methyl salicylate 2%, isopropyl alcohol ad 100%. Hoffman (1941) recommends the local application of chloroform. Very hot water is an excellent counter irritant for blackfly bites. With the recent emphasis which has been placed on the allergic nature of the reaction, has come the use of antihistamine preparations which have been well reported on (Gordon & Crewe, 1948).

INTERNAL PROTECTIVE PROCEDURES

The possibility of immunizing against the effects of the bites of blood-sucking flies has long aroused interest. That such a procedure would be practicable at least for blackfly bites, is strongly suggested by the observation that deaths of cattle from blackfly attack nearly all occur within the first 24 hours (Rempel & Arnason, 1947). The development of partial immunity to the effects of mosquito bites has been reported by Mellanby (1946) and has been confirmed by West (*In litt.* 1952) for northern *Aedes* species. As early as 1923 Georgevitch obtained a toxin from the heads of blackflies, to which an immunity was developed in animals. Although more progress has recently been made, and experimental antigens for blackfly bites are now available, there are two principal obstacles; first, the tremendous variation in the reactions of individual people to bites, and secondly, the lack of general agreement as to the cause of the reaction, which has already been discussed. It appears also that there is a similar variation in the reactions of a given person to the bites of individual flies of any particular species. These facts, and the absence of any absolute criteria or standards of comparison make it very difficult to evaluate progress in this field.

So long as immunizing techniques require a series of injections and give only short term results, they are unlikely to have much popular appeal; the bites of the flies will themselves render this service at less expense. For military and other special purposes, however, already existing techniques may prove useful.

Interest in dietary protection, or repellents for administration by mouth, first proposed by Ochman in 1911 (Graybill, 1914) has recently been revived. Attractive though this idea is, logical progress in this direction can only come after the factors responsible for the variation in attractiveness between different individuals, as distinct from the variation in severity of reaction, are better understood. It is perhaps necessary to draw a distinction here between repellents for oral administration, and the killing of biting flies by oral administration of an insecticide, to circulate in the blood stream. This latter has been attended with more success, at least in veterinary applications, but although the two procedures overlap, it does not come within the scope of this article. A great many materials have been tested in this way, including many of the vitamins, sex and other hormones, volatile oils, alkaloids, and chemicals used as repellents on the skin (Kingscote, 1951). As yet, however, although Shannon (1943) found thiamin chloride effective, Wilson *et al.* (1944) were unable to confirm this, and at present there are no promising leads.

The psychological effects of biting flies present a more difficult problem than the physiological effects. Methods of protection against them have not been investigated, but the knowledge that adequate protection against the physiological effects is available is likely to prove helpful. Probably a contribution to the solution of this problem could be made through an indoctrination program on the lines indicated by Shelesnyak (1947). Through the normal educational media of films, lectures and pamphlets, some knowledge of, and above all interest in the biting flies could be imparted. Such knowledge should emphasize pleasanter aspects of the flies; the improbability of disease transmission, acquired immunity resulting from bites, and the small amount of blood taken. The more interesting gaps in our knowledge of these insects should be presented: the psychological threat is greatest to the incompletely occupied, and nobody with an interest in biting flies will be unoccupied when flies are around. Such mass amateur observations might contribute little to knowledge, but a great deal to morale. It seems likely that people should also be taught to control the removal reaction; there may be physiological as well as psychological grounds for this.

The threat of the biting fly can certainly be mitigated by the cultivation of an attitude of patient tolerance; by learning to accept these insects as an essential feature of an environment which offers compensations in other directions. Getting used to these pests and learning to live with them should be a part of the training of all who live in the north, since it is certain that despite aeroplanes and DDT, and anything that these may immediately foreshadow, the biting fly will be a feature of life in the north for many years to come.

SUMMARY

Information on the factors which influence the attraction of northern biting flies, mosquitoes, blackflies, and tabanids to man and their subsequent feeding on his blood is reviewed. The effects of these insects on man and animals are discussed with some emphasis on the psychological effects which may be no less important than those of a physiological nature. Procedures to minimize this attraction and feeding, and to mitigate these effects are considered. It is concluded that the best protection is afforded by a judicious combination of partially protective clothing, including a fringed hat in preference to a net as head protection, with a standard repellent. A new type of container for insect repellents is proposed. These physical protections should be supported by a proper attitude of mind towards the insects, which can be inculcated by educational procedures.

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ARTICLES

EASTERN EQUINE ENCEPHALITIS IN THE UNITED STATES *

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Although Eastern equine encephalitis (EEE) was not recognized as a distinct disease entity until 1933, there is good evidence that this malady has caused severe epizootics among horses and mules in the United States for at least 100 years. Many of the outbreaks formerly designated as cerebrospinal meningitis, blind staggers, and forage poisoning were no doubt caused by the virus of Eastern equine encephalitis. These included the outbreaks of 1847 in Long Island, New York (1), of 1902 in North Carolina (2), and of 1912 in Maryland, New Jersey, and Virginia (2, 3).

During the past 20 years, the Eastern type virus has caused outbreaks among horses, humans, and birds in various sections of eastern United States. At present this virus has been demonstrated in 17 states—all except Michigan, Missouri, Arkansas, and Tennessee located along the Atlantic seaboard or the Gulf of Mexico (4, 5, 6).

Outbreaks of Eastern Equine Encephalitis in the United States. Notable outbreaks (principally epizootics) of EEE during recent years include the following: (1) 1933 along the North Atlantic coast; (2) 1938 in New England; (3) 1939 along the South Atlantic coast; (4) 1941 in Texas; (5) 1942–43 in Michigan; (6) 1947 in Louisiana and Texas; and (7) 1949 in Louisiana and Arkansas.

The 1933 epizootic, centered along coastal and tidewater areas of Virginia,

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