

FLIES AND FLEAS AS FACTORS IN THE DISSEMINATION OF DISEASE. THE EFFECTS OF PETROLEUM AS AN INSECTICIDE.

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OF late more attention is being given to the rôle of insects as carriers of disease. Malaria, yellow fever, and filaria are carried by special varieties of the mosquito. The bed bug has been shown to carry the spirillum of relapsing fever; a tick, red water fever; the tsetse fly, sleeping sickness; the flea, plague; and more recently the owl midge (a special variety of the sand fly), the special form of three-days Mediterranean fever.

Much evidence has accumulated against the common house fly and other flies as carriers of typhoid, infantile diarrhoea, bacillary dysentery, cholera, tubercle, diphtheria, erysipelas, contagious ophthalmia, cerebro-spinal meningitis, anthrax, and possibly other diseases, such as smallpox.

With regard to the first of these diseases, Cols. Firth and Horrocks, of the Royal Army Medical College, London, have shown that enteric stools may contain from three to five typhoid bacilli in '006 milligramme, almost an infinitesimal amount of dejecta. When the number and volume of evacuations from a single patient are considered one can realise the enormous possibilities of infection unless the dejecta are at once removed, burnt, boiled, sterilized, or deeply buried. It is a fact also that long after convalescence the typhoid bacillus is voided in the urine, according to some observers in at least 25 per cent. of cases.

It is now proved also that the typhoid organism may retain its vitality in the human alimentary canal for an indefinite period extending, as in the case recorded by Prof. Dean, of Aberdeen, up to twenty-nine years after apparent recovery from the disease. Outbreaks of enteric fever have now been shown not to be exclusively water-borne.

Anyone who had any doubts on this subject may lay them aside in the light of the evidence from the epidemic in Auckland last year, where parts of the city and suburbs remained immune when the disease was rife in other parts receiving the same water supply, which bacteriological tests also showed to be unpolluted. With regard to pollution of the air, there is practically no evidence of enteric fever in this respect resembling bacillary dysentery, diarrhoea, and cholera, unlike most other infectious diseases, being carried direct from one patient to another by means of air.

In the case of typhoid it has not been necessary to look for an intermediate stage of existence on the part of the bacillus, such as we are familiar with in the case of malaria, where the duodenum of the mosquito is a necessary temporary habitat during one stage of the development of the living virus. Ordinary house flies convey enteric-infected material not only on their legs, wings, and bodies, but also on their heads, more especially on the mandibles. This is easily shown in any laboratory by getting a fly to walk over a plate of media on which there are cultures of any pathogenic or other organisms, and then transferring it to a sterile plate. Each fly has six legs, on each of which are two pads, each conveying 1,200 hairs. Each of these 7,200 hairs secretes a sticky fluid. It is this fluid which allows a fly to walk upside down on a ceiling. The mechanism is that the points are raised when the pads adhere to anything, and lowered when it is desired to take another step. Thus, by the pressure of their points against the ground and the lifting of the heel the pads are released. When flies stick to a wall, as in the autumn, it is owing to them becoming too weak to use this mechanism, so that the glue becomes hardened and set.

Flies breed in almost any decaying animal or vegetable matter, horse-dung being especially a favourite breeding place. The eggs are long and white, and are hatched in six to eight hours into white pointed maggots. These grow with enormous rapidity, cast their skins twice, and under suitable conditions reach full growth in four to five days, then the outer skin becomes hard, swells up, and turns dark brown. Within this is the true pupa, from the anterior end of the brown covering of which the adult fly five days later issues. Thus, a single generation comes to maturity in ten days, and it is said that as many as twelve generations are developed in one summer in some countries. Dr. Jackson, of New York, has estimated that each fly during the season lays 1,000 eggs. Thus it is easy to account for the enormous number of flies wherever there exists organic filth or food, on both of which they feed.

In 1907 I made some interesting observations on the breeding of flies at Motuihi, the quarantine island in Auckland harbour, and repeated them in the laboratory. The most interesting point noticed was the disappearance of the maggots for a time to take up a pupa or intermediate stage in the superficial layers of the earth.

Major F. Smith, D.S.O., has shown in the Royal Army Medical College Journal that the larvæ, if the soil is impermeable to them, will travel as at least ten feet to find suitable ground. Major Smith concludes that in India, where the whole country is littered with fæces, the flies bred out of excrement deposited on the ground by men and animals are greatly in excess of the number from any other source, whether in or out of cantonments.

Recently we have placed pieces of meat exposed to flies in specially constructed cages of wood and gauze. The maggots made for the floor of the cage. At first, when we placed earth in the cages, we found the fly went through the stages of development described above. As a result of further experiments without earth, we have bred flies direct from the meat, the maggots and pupæ simply honey-combing the flesh. Thus we have demonstrated that it is not essential for the breeding of flies that the pupæ should develop in earth.

An interesting experiment in our laboratory was the placing of flies on gelatine media; not only did we obtain organisms, chiefly the *B. Putrefaciens*, but also thirteen maggots from one fly. These maggots bored their way into the gelatine and were suffocated. Maggots kept in corked test-tubes apparently died in four hours, but on admitting air, revived. A lighted taper placed in a test-tube in which maggots had been kept was extinguished, thus showing that, although carbonic anhydride was formed, it did not kill the maggots as quickly as higher forms of animal life.

The United States Department of Agriculture has recently published a report by Prof. Howard, their entomologist, in which it is stated that, assuming that only half of a fly's output of eggs hatch out and live to raise families of their own, in thirty days the number of flies would be 216,000, and in forty days over twelve millions. Allowing 1000 flies to the ounce, we find that the total produce of one fly at the end of forty days would weigh 810 lbs., or more than five times the weight of a 160 lb. man. Thus, no further argument is needed to show the importance of endeavouring to exterminate the house-fly at the beginning of the season as far as possible.

Prof. Santoni, from cultures derived from flies frequenting a Roman market-place, isolated a bacillus which morphologically and by culture tests

was identical with the organism shown by Dr. Volpino to be most frequent in epidemic infantile diarrhoea.

Although in the laboratory it is easy to show that pathogenic organisms pass through the alimentary canal of a fly, yet it is not claimed that they transmit disease otherwise than as mechanical carriers of germs.

Whilst working in the Quarantine Laboratory at Port Said in 1906, I obtained *B. Coli* from the excrement of flies. Owing to the danger of infection, flies being very difficult to keep under control in transferring them from one medium to another, I have not experimented with typhoid stools or cultures.

Dr. Fricker has shown that flies fed on typhoid cultures give off the bacilli twenty-three days after infection. Typhoid bacilli were found in the intestine nine days after feeding on typhoid materials.

Whilst serving with Plumer's column in South Africa I recorded in the *Lancet* the observation that, whilst other columns suffered largely from typhoid, we remained comparatively immune until after we had rested a fortnight in a standing camp at Wakkerstrom. The reason we escaped during our first nine months' service was probably due to the fact that we seldom camped two days running in the same place, and seldom reoccupied a previous camping-ground. Coincident with the outbreak of typhoid we had a plague of flies. The latrines speedily became their breeding and happy hunting ground in the intervals between their visits to the supply stores and the different messes. Had the bugle been the signal to go to mess, one could almost have believed that the flies knew the call.

Although convinced of the part flies played in carrying disease from having seen them feeding on typhoid stools in South Africa, in Egypt on the pus of contagious ophthalmia, and in the Sinai Peninsula on the excreta of pilgrims dead and dying of bacillary dysentery, perhaps one of the most striking cases of fly-infection within my ken was that at the outbreak of the typhoid epidemic in Auckland last year.

Ever on the outlook for instances of the conveyance of infection by flies, advocating *ad nauseam* the regular removal of all organic refuse, more especially stable manure and excreta (favourite breeding grounds) as well as the use of kerosene as an insecticide, I hardly expected to come across so remarkable an example of this method of typhoid conveyance. On the removal of one of the earliest cases to hospital the relatives left the infected house. A wooden box (the usual receptacle in that suburb at that time) contained the discharges of the patient. "Because it was not full" on the occasion of his fortnightly visit the contractor's man did not remove the contents. The flies immediately proceeded to do so. Some

days later, our inspector, Mr. Grieve, found the box "swarming with maggots." Small wonder that even in a small borough with a population a little over two thousand, we had twenty-three cases in two months. Around the first house affected the other cases occurred in such a way as to show a cluster of flags round this centre on a spot-map. In a letter last May Prof. Kenwood, speaking of this, wrote, "The fly-borne outbreak at Newmarket is one in which the evidence is very direct and convincing."

The dry-earth or pail-closet system in towns is therefore absolutely reprehensible from a sanitary point of view; especially in New Zealand, where there is great difficulty in getting labour to remove the pans, and a total lack of co-ordination between urban and rural authorities as regards the latter permitting the use of land in their areas.

In Auckland Province there were 353 cases of enteric fever for the year ending 31st March, 1908, of which 194 cases were in Auckland city and suburbs. Of these 214 cases, or 60·6 per cent., were in the first three months of the calendar year, giving an average case-rate of 71·3 per month, as contrasted with 18·4 for the previous nine months. The average temperature for the first three months was 66·8°F., for the previous nine months 56°, and for the following nine months 56°F. In these months (January, February, and March) last year flies were most prevalent.

The records of typhoid cases admitted to the Auckland hospital for the last fifty years, indicate a steady rise from November to April, attaining the maximum in the latter month. Last year the epidemic reached its zenith a month earlier, thus repeating the experience of other countries where "the hot dry months show the heaviest enteric bill." Coincident with the spell of hot weather we had a plague of flies. Although, until recently, no records have been made to show in which month flies were most prevalent in Auckland, such records have been made in New York by placing cages at various parts of the city, and counting the flies caught each day. Whenever flies became prevalent the death-rate from intestinal diseases rose above the normal, and fell off with a slight lag at the time of the gradual falling off of the prevalence of the insects.

The filthy feet of faecal-feeding flies walking over meat, butter, bread, cake, sugar, jam, or any food, as well as the predeliction of flies for milk, shows how easy is the acquirement of typhoid fever, when one knows that one fly can carry 100,000 organisms.

The prevention of this source of infection is to prevent the accumulation of any organic refuse in or near a house, and so minimise the material on which they can breed. Wherever possible a water-carriage system of sewage

should be introduced, and where this is not possible, and an earth closet or dry conservancy system must be retained, every attempt must be made to see that the ventilator of the privy is screened off from flies, and that petroleum is put either in the pan or mixed with the earth. All food in private houses should be screened, and no food of a perishable nature should be allowed to be sold unless it is kept secure from flies. The Auckland City Council have decided to bring in regulations chiefly with the view of preventing fly infection in butchers' shops, and will probably also follow the lead of Sydney in refusing to allow milk to be kept in dairies other than in fly-proof safes.

In this country, apart from rats, the presence of fleas in houses is due to the keeping of flea-infested dogs, and in some cases cats. With regard more especially to the former, a night spent in a Maori whare would convince anyone of this. Fleas naturally live upon the animals which they infest, or upon man, special varieties being found on different animals. The eggs laid by the fleas may fall on the floor or the carpets of houses, and, after hatching, live for an indefinite period upon the dust which accumulates under carpets and in crevices and joints in the flooring. Thus to rid a house of fleas attention should first of all be directed to any domestic pets, which should be treated by rubbing them with kerosene mixed with three parts of some ordinary oil, such as linseed oil, to reduce the strength. Where it is not advisable to prolong the use of kerosene in houses after carpets and furniture have been replaced, owing to the disagreeable odour, it is best to use a 10 per cent. solution of creolin. As a substitute for creolin, which is not easily procurable in this country, one of the disinfectants introduced by the firms which have established reputations for sheep dips, Little's, MacDougall's, or Quibell's, known by the trade names of Phenyl, No. 5, or Kerol should be used.

Schools can be kept free of fleas by using sawdust saturated with such disinfectants sprinkled on the floors and by a weekly scrubbing, using water in which a disinfectant has been dissolved. Sprinkling animals with pyrethium powder will also keep fleas away from them.

With regard to bugs in Auckland, at one of the receiving cells at the prison we were able to get rid of these pests by swabbing out with kerosene. In connection with these insects an interesting point has come under our notice recently, consequent on the successful extermination of cockroaches by the use of a substance invented by Mr. Pruden of Tauranga. We have found on some old ships where cockroaches have been exterminated that bugs have come into evidence. We know now

that the best way to keep down the latter is to introduce the former, and when the cockroaches become so numerous as to become a nuisance attack them with Pruden's preparation.

With regard to the use of kerosene to keep down flies, my attention was first drawn to this by Surgeon-General Hamilton, I.M.S., Umballa, with whom I had been drawn into a controversy in the *B. M. J.* on the extermination of mosquitoes by petroleum. Whilst acting as *Médecin des Hôpitaux* at the great Hedjaz Pilgrimage Camp at El Tor in 1906, where we had in one hospital during two months 110 deaths from bacillary dysentery, I was so impressed with the persistent way in which the flies hovered round the dead and dying that I enquired of Colonel Hamilton as to whether they had any way of dealing with the pest of flies in India. Although he pooh-poohed the idea of the use of petroleum against mosquitoes on a large scale, he was the first to suggest the syringing of latrines with kerosene, telling me that the incidence of flies and also typhoid had been much less since he introduced this practice into the Indian cantonments under his charge.

Last year, my attention having been drawn to a plague of flies which congregated so thickly on the Rangitoto wharf as to make the lower surface of the structure black, advantage was taken of a visit of some parliamentarians to Motuihi to demonstrate the effects of kerosene as a fly exterminator. Inspector Grieve of the health department spent an hour syringing the wharf with kerosene. The bottom of the boat from which he operated was over an inch deep with dead flies, and except in places where the kerosene had not reached the flies disappeared. Owing to the fact that kerosene evaporates so quickly there is no danger from fire.

In one of the largest butchering establishments in Auckland it was found that although the rubbing of a cloth damped with kerosene would keep the flies away from a mirror for twelve hours, owing to its rapid evaporation it was necessary to apply the oil twice a day to get any continuous benefit.

In combatting flies, therefore, petroleum for practical purposes has its limitations, wherever there is a nightsoil system, however, it should be used. Recently a special pan, known as the Farmer sanitary pan, has been introduced, by which oil is distributed over the contents of the receptacle each time it is used. We have found, however, as the result of experiments carried out by Mr. Symons of our department, to whom I am indebted for much assistance in investigating the habits of flies and watching the experiments in the laboratory, that the sprinkling of earth

over which kerosene has been poured acts perfectly in keeping flies away from nightsoil pans.

The introduction of stringent regulations to protect meat, milk, butter and other perishable foods, as well as the regular cleansing and daily removal of stable manure, the encouragement of motor traffic, and the removal of fowlhouses from towns, will go far to remove this pest from round our dwellings.

Everyone is familiar with the fact that petroleum is now the most efficient remedy for the removal of nits and pediculi capitis.

Those who are troubled with ants of any species can also get rid of them by its use.

The use of the patent oil-broom with an oil reservoir either for sweeping rooms, or, by the adoption of a larger size, for street sweeping is also to be commended.

A point noted at Motuihi was that the encouragement of the breeding of fly-catchers, such as the fan-tail, considerably lessened the number of flies. The introduction of insectivorous birds into Australia and New Zealand, such as the sand-martin and the pied fly-catcher, for which the country is well adapted, would probably keep down the number of flies, mosquitoes, and culices. If for no other reason than to allow us to grow green vegetables without having them fly-blown, from an economic point of view such an experiment should receive a trial, say at Tauranga experimental farm, where the climate is suitable for such birds.

As again illustrating the truth that there is nothing new under the sun, the fact that oil was poisonous to insects was known to the Ancients. Thus Lucian of Samosata, a contemporary of Trajan, speaking of the fly, wrote:—"It is in man's company as long as it lives, and takes the freedom to taste of all his food, oil only excepted, because it is poisonous to him. For him are goats milked, and the bees make honey for the flies as well as for men. For him do the confectioners make their sweetmeats, and he tastes them before the kings themselves, with whom he feasts, marching about the table, and eating with them in all things."
