LIFE-HISTORY AND BIONOMICS OF THE CAT FLEA, *CTENOCEPHALIDES FELIS* BOUCHÉ.[1]

BY

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(*With six text figures*)

CONTENTS

LIFE-HISTORY

Fleas are holometabolous insects. Eggs are laid generally in such places where the host animal rests during the night and where the larvae on hatching can obtain their food without much difficulty. Some of the locations selected for egg laying are dirty corners, under the carpets, in straw mattings, cracks and crevices in the floor, unclean chicken houses containing dried excrement, feathers, straw, etc.

Ctenocephalides felis oviposits in the fur-covering of its host (cat) and also near the breeding places of the same animal. Plenty of eggs were obtained from a blanket which formed the bed of a kitten. Observations on the mode of oviposition were made with the help of the *draw tube technique* described below.

A glass tubing was drawn out to form a fine narrow pipette with a lumen which would hold a number of fleas in a single row. The end of the pipette was closed, and flea specimens were introduced into it and blown with mouth towards the closed narrow passage. The movements of the fleas thus enclosed in the narrow passage in a single row were observed with the help of a low power microscope.

Egg

Just prior to actual egg-laying, the flea wriggles about restlessly and shows very rapid movements of the legs and the mouth parts. Suddenly after this a little quantity of fluid excretion is ejected with a considerable force through its genital aperture, and immediately

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afterwards, an egg is launched out and deposited into the fluid. The process is repeated and more eggs are deposited in the same manner. The flea under observation was found to deposit three eggs in quick succession.

A female *Xenopsylla cheopis* is reported (14) to deposit from 2 to 6 or even more eggs at a time, and is capable of laying 300 to 400 eggs during its life-time. In the case of *C. felis* a female laid over 800 eggs during its life-time.

Eggs of *C. felis* are just visible to the naked eye, their average size being about 300 microns (Fig. 5). They are broadly oval in shape and glistening white in colour. The surface of a freshly laid egg is perfectly smooth, but when dry, it shows a faint reticulum spread all over in a discontinuous way. Unlike the eggs of other fleas which become dull and darkish with age, those of the cat-flea remain relatively unaltered in colour, except that they become a little opaque.

Minute micropylar openings which provide passage to the spermatozoa during fertilization, are situated at each pole of the egg and arranged in circular rows. There are 35 to 55 such openings at the anterior pole of the egg of *C.felis*, and 20 to 30 at its posterior pole.

Larva

The eggs hatch after 2 to 4 days into a tiny worm-like apodous larva which moves about actively and away from light by means of bristles which encircle its body segments (Fig. 1). When full grown, it measures about 4 mm. in length. It has a distinct head, three thoracic segments and ten abdominal segments. The midportion of the body covering the seventh and eighth segments is the broadest. The body tapers towards the anterior and posterior extremities, the head and the terminal abdominal segment being the smallest. The latter bears a pair of stout, blunt, hooked, chitinous processes called

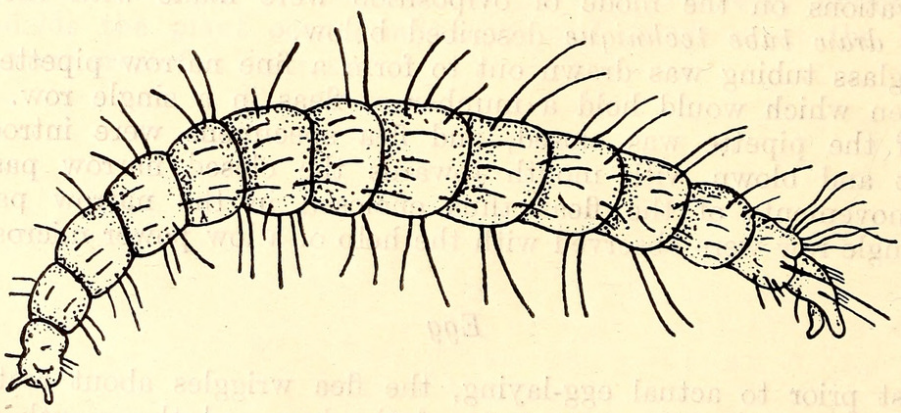

Fig. 1. Larva of *C. felis*.

the anal struts. The head which is of the prognathus type is more chitinized and darker in colour than the body-segments. It bears a pair of slender cylindrical antennae. The ocelli are absent. The mouth parts which are of the biting-crushing type, consist of the labrum, a pair of mandibles, a pair of maxillae and the labium.

The larva, unlike the imago, is not parasitic in its feeding habits. It feeds on the organic debris found on the body of the host. An examination of the contents of the larval stomach reveals the presence of blood and blood-pigments. Obviously their source lies in the organic debris which is usually formed of the faecal matter of the adult fleas containing half-digested blood. Occasionally the larvae occur on the hind region of the body and in the dirty pelt of the host. Larvae of other species of fleas are also found at times on the body of nestling birds and also on human beings with unclean habits. Here they probably feed on the organic material present on the skin of the host which at times contains blood defaecated by the parent flea. The presence of this blood can be demonstrated in the form of minute dark-coloured particles on the fur or feathers of such animal hosts.

The larva passes through three consecutive instars. The length of the larval life is not definite and generally varies according to the temperature and humidity conditions of its surroundings. Generally speaking the larval life extends over a period of 9 to 10 days. Towards the end of this stage, the larva surrounds itself with a silken cocoon (Fig. 6) spun from its own salivary secretion. Pieces of debris are incorporated in the walls of the cocoon with the result that it resembles its surroundings so closely that it is very difficult to spot it out. Often several cocoons adhere together to form masses which then become visible to the naked eye. When the cocoon is completed, the enclosed larva moults into the pupal stage.

Pupa

The pupa resembles the adult. In a full-grown pupa which is whitish in colour, the segmentation of the exoskeleton can be clearly seen (Fig. 2). The head is bent ventrally and the palps and the

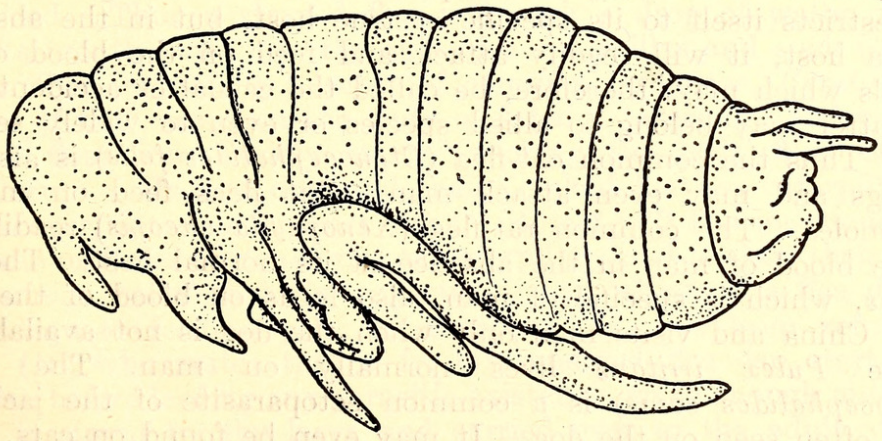

Fig. 2. Pupa of *C. felis*.

legs lie folded and well-pressed against the ventral surface of the body. The duration of the pupal stage is from 7 to 10 days, after which the pupa moults into the *imago* (Fig. 4). Thus the whole life-cycle of the flea is completed within a period of about three weeks.

The life-cycle period may be shorter in the case of tropical fleas living under optimal conditions, with a temperature of 23°C. and humidity from 80% to 90%. Observations on the development of the dog flea (*Ctenocephalides canis*), according to Russel (17), indicate the duration of the different stages as follows:—egg stage—2 days; larval stage—6 days; pupal stage—8 days; total period of the life-cycle—16 days. However, under extremely abnormal conditions, such as low temperature and scarcity of food, the life-cycle of the flea from the egg to the adult may take a much longer period, which, as reported by Jordan (18), may in some cases extend from 18 to 20 months.

Very often the imago may remain quiescent in the cocoon for a very long time before it emerges from it to lead a free active life. Waterston and Jordan (25) state that a mechanical stimulus from outside, however slight, is required for the resting imago to break through its cocoon, and in the absence of that stimulus, the emergence is very often delayed. They also state that the required stimulus is usually supplied by the host itself by brushing against the resting cocoons which thus become activated, and emergence follows.

More striking is the behaviour of certain fleas such as *Ceratophyllus styx*, which leaves the cocoon before the arrival of its emigrant host, the sand martin, and instinctively waits for it near the entrance of its burrow. This probably accounts for the sporadic outbreak of fleas after long intervals.

After emerging from their cocoons fleas can live without food for a considerable period of time. When sexually mature, copulation takes place and the cycle starts over again.

Bionomics

Hosts of Fleas

The normal food of the fleas is the blood which they obtain from the hosts on which they live a parasitic life. As a general rule, a flea restricts itself to its specific or true host, but in the absence of such a host, it will readily attack and feed on the blood of other animals which may, therefore, be called the casual or accidental host. The latter may belong to allied species or even to widely separated ones. Thus the common cat-flea (*Ctenocephalides felis*) is also found on dogs and may even attack man. Rat fleas feed on mice and even moles. The common rat-flea (*Xenopsylla cheopis*) readily feeds on the blood of man in the absence of its normal host. The *Pulex irritans*, which is specific of man, also feeds on blood of the dog in North China and visits man only when the dog is not available. In Europe *Pulex irritans* lives normally on man. The dog-flea (*Ctenocephalides canis*) is a common ectoparasite of the jackal and is not often seen on the dog. It may even be found on cats. Many animals exchange fleas with one another due to their living close together. That is why the bird fleas are found on mammals or even on bats. Beasts of prey are infested with fleas from the victims on which they prey. Thus rabbit fleas are found at times on wild cats. Russel (17) has stated that a German naturalist collected 2,036 fleas from theatres, concert halls, ball rooms, schools and

barracks in the great Duchy of Baden and found that 50% of them were dog-fleas. In zoological gardens cat-fleas are generally numerous in most cages.

Probably more species of fleas have been obtained from Insectivora and Rodents than from other Orders of Mammals taken together. It may, however, be mentioned here that Ungulates and monkeys are the only mammals generally free from the flea trouble. Russel (17) suggests that Ungulates are immune to fleas, due to the fact that their young ones always follow their mother from the time of their birth, instead of leading a stationary, helpless life in their shelters. It has also been observed that the relationship between a flea and its specific host is often characterised by individual preferences. Thus the human flea will readily feed on the blood of a particular person and reject that of another although belonging to the same species.

Feeding Habits

Some fleas may remain attached to the body of their specific host nearly throughout their life and thus prove to be highly parasitic in habit, while others may act only as temporary parasites. Female fleas belonging to the family *Hectopsyllides* (*Sarcopsyllides*) fix themselves to the body of their host and remain attached in one position for a greater part of their life. The 'Jigger' (*Tunga penetrans*) may be mentioned as an example of this habit. The females may even bore through the skin and oviposit subcutaneously. Other species bite occasionally, taking short feeds, and still others may take a long feed and then hop away from the body of the host to return once more after a lapse of time. Many species of fleas do not suck blood more than once in their life. As a general rule, fleas are temporary parasites. When the temperature is high, the process of digestion takes place rapidly in fleas as in other insects. Thus the number of feeds is closely correlated with the rapidity of digestion which, in its turn, is governed by temperature conditions.

It is rather a remarkable fact to note that some fleas, under conditions of starvation, will resort to taking in liquid food other than blood. Thus a starved flea will suck a drop of water or even insert its mouth parts into the skin of a caterpillar and suck its fluid. Damph (6) introduced a number of common bird fleas (*Ceratophyilus gallinae*) of both sexes on the body of a hairy caterpillar and observed that the fleas immediately started sucking the body fluid of these insect larvae. He also observed that a naked hairless caterpillar was not, however, attacked by such fleas. Russel (17) has mentioned that the larvae of *Pulex irritans* prey on caterpillars and feed on their juices. The common belief that the capacity of oviposition of a flea depends upon adequate feeding prior to that process, has been refuted by Jordan (18) who states that a freshly emerged flea can start laying eggs even before leading any parasitic existence, since enough nutritional matter is stored by the larva and carried over to the adult stage to enable a certain number of eggs to get ripened. Several successive generations have been observed to have been produced in this way. This fact easily accounts for the excessively large number of fleas found sometimes in uninhabited huts and other locations such as grain storage, etc., where the normal food is not available.

Mode of Feeding

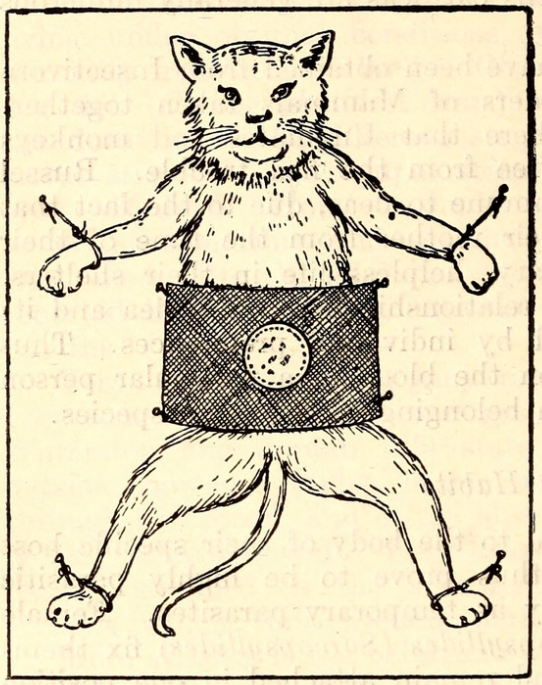

Fig. 3. Demonstrating the mode of feeding.

Observations on this point were made with the following technique. A kitten was first laid on its back on a dissection wooden board and its limbs were tied by strings on to nails fixed to the corners of the board (Fig. 3). Its head was then adjusted in position by means of a leather strap fitted across its neck. Its belly was shaved so as to make the skin clean and bare. A square piece of clean white flannel with a median circular hole of about an inch in diameter was spread and tied to the belly. Another piece of soft wire gauze with a close meshing and of the same size as the flannel piece was taken and had a median circular aperture of the same size cut into it. The wire gauze was then spread over the flannel piece in such a way that both the apertures coincided with each other. The gauze was then fixed to the board and a flea starved for about a week, was introduced on the portion of the belly exposed through the apertures. A watch glass was immediately placed over the aperture in order to close it and trap the flea within the circular area. Movements of the flea were then observed with the help of a binocular dissecting microscope.

Before the stylet-like piercing mouth parts were inserted into the skin of the host, a flea was seen wandering about on the surface of the skin, as if for the purpose of exploration, making occasional punctures here and there. When an appropriate spot was discovered, it immediately took up a tilted position. The epipharyngeal and the mandibular stylets were then thrust into the skin, while the furcate labium was bent outwards, the palps forming an angle with the submentum. The forelegs spread outwards and thus balance the posterior region of the body high above the surface of the skin. So long as it was not disturbed, it remained absolutely glued to the spot. In this position it could be examined from all sides with the help of a powerful lens or a telemicroscope. Within two or three minutes one could see its abdomen gorged with red blood. Careful observations also revealed the up-and-down movements of the mandibles and the passage of blood through the pharynx into the pulsating mid-gut.

Locomotion and Means of Distribution

The normal mode of locomotion in fleas is by jumping from place to place. They can also glide their way easily through fluffy objects, such as fur, cotton, wool, flannel, etc. Being habituated to this type of locomotion in the furry coats of mammals, birds and such

other hosts, certain structural adaptations have been developed by them. They have a bilaterally compressed body covered with spines and bristles all of which are backwardly directed. In the case of the combed fleas like *Ctenocephalides*, the spines of the comb are also similarly directed. The antennae being delicate and sensitive, are lodged within the antennal grooves, the eyes are protected by the *'ocular'* and *'frontal'* bristles. If disturbed, they often sham death and rest with their legs tucked in tightly to the body, in which condition they may even be blown about. With the help of their powerful legs they jump over long distances. Patton (14) states that

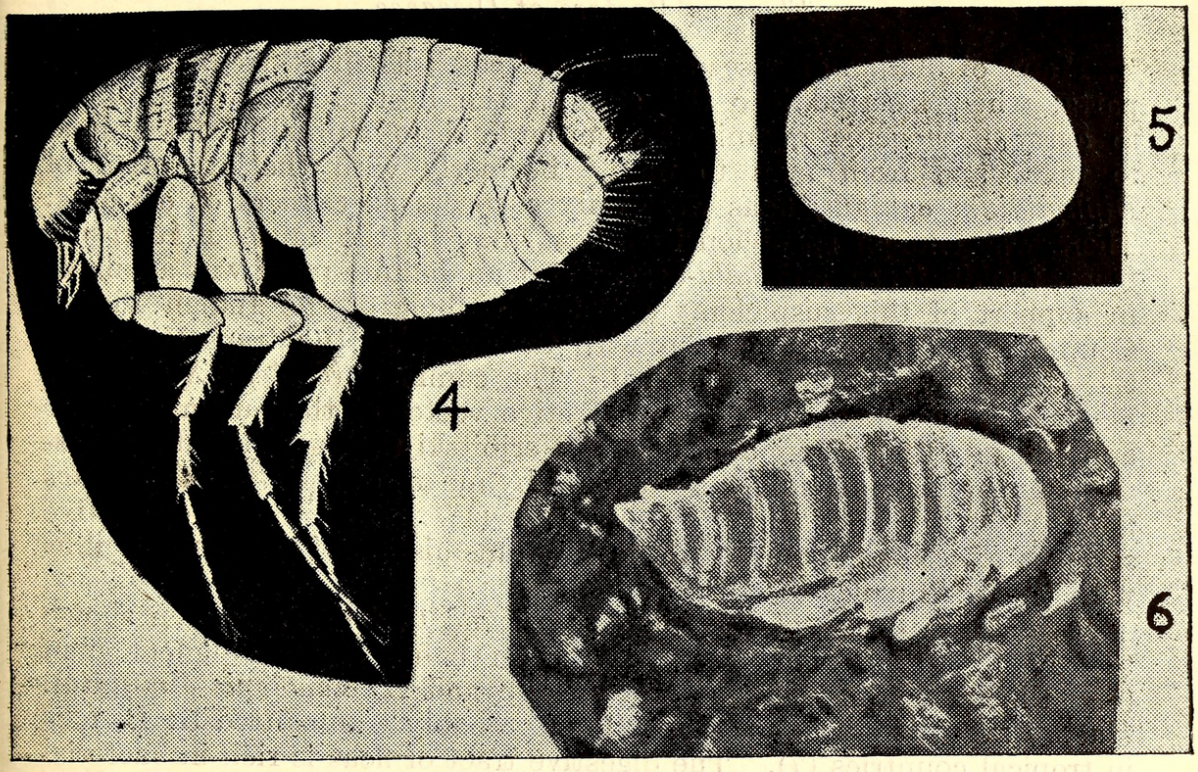

Fig. 4. Adult of *C. felis*.
Fig. 5. Egg of *C. felis*.
Fig. 6. Pupa exposed by cutting open the cocoon.

the longest jump a flea can take, measures over 33 cm., and the highest jump taken by it reaches a height of about 19·5 cm. When off the host, the fleas remain confined to the ground and cannot distribute themselves far and wide like winged insects. But they are carried from place to place through the agency of their hosts. Transport, especially sea-transport, helps a good deal in the distribution of fleas from port to port. Also the eggs which are frequently laid on the host are scattered about when the animal goes to its resting place.

Longevity

Observations made by Nicolle (12) on *Nosopsylla faciatus* indicate that the average length of life of the flea is from 6 to 8 days under ordinary temperatures. Experimentally however fleas have been kept alive for several months. Bacot (2, 3) for instance, had kept *Pulex*

irritans in the living condition for 513 days. *Xenopsylla cheopis* lived for 162 days [Webster and Chitre as quoted by Patton (14)]. Strickland (21) kept fleas living as long as 17 months without feeding them at all during this period. Nicolle (12) states that under certain conditions the larvae and pupae of fleas remain unmetamorphosed for months and months. Jordan (18) also mentions that the pupa may lie quiescent within its cocoon for an indefinitely long period until it receives the requisite mechanical stimulus for its emergence. As regards *C. felis*, it was observed that the flea could be kept alive for over three months under experimental conditions.

Fleas as Vectors of Diseases

Many of human diseases are due to fleas. Their stylet-like mouth-parts, when inserted into the skin of the host, render them liable to carry pathogenic organisms from animal to animal, from animal to man, and from man to man. Formerly with the exception of *Diphylidium canium*, fleas were only suspects as carriers of diseases. There was enough suspicion that fleas may be the cause of *relapsing fever*, *typhus fever*, and *kala-azar*. But no definite proof was available in support of this suspicion, until the findings of the Indian Plague Commission (1), in connection with their role in the transmission of the plague germs, were published. The common rat-flea (*Xenopsylla cheopis*) is now known to be an effective vector of the bubonic plague and the murine (endemic) typhus. Verjbitski (24) successfully transmitted the plague bacilli from rat to rat by means of the *Ctenocephalides felis*. The Indian Plague Commission (1), during their exhaustive series of experiments, succeeded in the transmission of the same bacillus with the human flea (*Pulex irritans*).

Ctenocephalides canis, *Pulex irritans* and *C. felis* have been shown to be the intermediate hosts of certain helminths that affect man (e.g. the tapeworms *Diphylidium canium* and *Hymenolepis diminuta*). *Haemorrhagic septicaemia* of cattle is probably transmitted by *C. felis* in tropical countries (7). The digestive tract of fleas is rich in bacterial flora and protozoal fauna. That the flea is a potential reservoir of protozoal infection, has been shown by various workers prominent amongst whom have been Balfour, Cowdry, Korke, Laveran, Minchin, Noller, Patton, Ross, Splendore, Swingle, Tyzzer, Wenyon, Yamasaki and others. As a result of the laborious work done by these workers in different parts of the world, remarkable facts about protozoal and spirochaetal infection by fleas have been revealed. Recent researches in insect microbiology have shown that *C. felis* has also been found to be a carrier of some unnamed species of *Crithidia* (20) and *Rickettsia ctenocephali* (20).

References

1. Advisory Committee (1906-1914): 'Reports on Plague Investigations in India'. Vols. **1**, **2**, **3**.

2. Bacot, A. W. & Martin, C. J. (1914): *Journal of Hygiene.* (Plague supp.) 1914, p. 423, 1924, pp. 23-98.

3. Bacot, A. W. & Ridewood, W. G. (1914): 'Observations on the Larvae of Fleas'. *Parasitology*, **7**: 157-175.

4. Balfour, A. (1906): Herpetomonas parasites in Fleas. *Journ. Hug.*, **6**: 652.

5. Cowdry, E. V. (1923): 'The Distribution of Rickettsia in the tissues of insects and arachnids'. *J. Exptl. Med.*, **42**: 231-252.
6. Dampf, A. (1907): Die Ost und Westpreussische Flohfauna. *Schriften der Physikokonom. Gesellschaft* zukonogsbergi-i-Pr., **48**: 388.
7. Daubney, R., Hudson, J. R. & Roberts, J. I. (1934): *J. Comp. Path*, **47**: 211.
8. Korke, V. T. (1916): On a nosema (Nosema pulicis, n. s.) parasitic in the dog-flea (Ctenocephalus felis). *Indian Journ. Med. Res.*, **3**: 725.
9. Landois, L. (1865): 'Anatomie des Hundeflohs (Pulex canis Duges)'. *Nova Acta Akad. Leop. Carol.*
10. Laveran, A. & Franchini, G. (1914): Infection naturelle du rat et de la souris au moyen de puces de rat parasités par Herpetomonas pattoni. *C. R. Acad. Sci.*, **158**: 450.
11. Minchin, E. A. & Thomson, J. D. (1915): The rat trypanosoma, Trypanosoma lewisi, in its relation to the rat-flea, Ceratophyllus fasciatus. *Quart. Journ. Micro. Sci.*, **60**: 463.
12. Nicolle, C. & Sparrow, H. (1935): *Arch. Inst. Pasteur Tunis*, **24**: 179.
13. Noller, W. (1914): Die Ubertragungsweise der Rattentrypano-somen II Teil. *Arch. Protist.*, **34**: 295.
14. Patton, W. S. (1930): 'Insect, Ticks, Mites and Venomous Animals.' Liverpool, Part II (Public Health).
15. Patton, W. S. & Rao S. (1921): Studies on certain Flagellate parasites of Pulex irritans L. Part IV, *Indian Journ. Med. Res.*, **8**: 621.
16. Ross, E. H. (1909): A gregarine parasitic in the dog-flea, Ctenocephalus serraticeps. *Ann. Trop. Med. & Parasit.*, **2**: 359.
17. Russell, H. (1913): 'The Flea'.
18. Smart, J., Jordan, K. & Whittick, R. J. (1943): 'A Handbook for the Identification of Insects of Medical Importance', London.
19. Splendore, A. (1920): Sui parassiti delle avicole. *Annali d'Igiene*, **30**: 445, 560, 622.
20. Steinhaus, E. A. (1946): 'Insect Microbiology'. New York.
21. Strickland, C. (1914): 'The Biology of Ceratophyllus fasciatus Bosc.. the Common Rat-flea of Great Britain'. *Journal of Hygiene, Cambridge* **14**: 129-142.
22. Swingle, L. D. (1911): The transmission of 'Trypanosoma lewisi' by Rat-fleas (Ceratophyllus sp. and Pulex sp.), with short descriptions of three new herpetomonads. *Journ. Infect. Dis.*, **8**: 125.
23. Tyzzer, E. E. & Walker, E. L. (1919): A comparative study of Leishmania infantum of infantile kala-azar and Leptomonas (Herpetomonas) ctenocephali parasitic in the gut of the dog-flea. *Journ. Med. Res.*, **40**: 129.
24. Verbitski (1908): 'The part played by insects in the epidemiology of the plague'. (In Russian).
25. Waterston, J. & Jordan, K. (1942): 'Fleas'. Brit. Museum (Nat. Hist.) Economic series, No. 3.
26. Yamasaki, S. (1924): Uber Leptomonas ctenocephali, Trypanosoma lewisi und pathogene Trypanosomenarten im Hundfloh. *Arch. Protist.*, **48**: 136.