

EXPERIMENTS ON THE SURVIVAL AND BEHAVIOUR OF THE ITCH MITE, *SARCOPTES SCABIEI* DeG. VAR. *HOMINIS*.

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The disease known as scabies or the itch is caused by the acarine parasite *Sarcoptes* burrowing in the horny layer of the cuticle of man. This paper describes experiments made with adult female parasites removed from scabies patients.

The Thermal Death Point.

The mites were exposed to known temperatures and humidities for periods of 10 to 30 minutes. The apparatus used consisted of a large boiling tube fitted inside a wide-mouthed thermos jar. The temperature was controlled within one-tenth

TABLE I.

Thermal Death Point of ovigerous Females for Exposures of 10 and 30 Minutes.

°C.	10 minutes Humidity uncontrolled		30 minutes Pooled results for 0 and 90 per cent. R.H.		°F.
	Nos. of mites		Nos. of mites		
	Dead	Alive	Dead	Alive	
53.0±0.2	5	0			127.5±0.4
50.9±0.1	5	0			123.5±0.2
50.4±0.6			3	0	122.7±1.0
49.5±0.5	11	0	7	0	121.1±0.9
48.9±0.4	8	0			120.0±0.7
48.5±0.5			11	0	119.4±0.9
47.8±0.1	3	7			118.1±0.2
47.7±0.5			11	0	117.8±0.9
47.4±0.6	2	12	13	2	117.7±1.0
46.9±0.3	0	8			116.4±0.5
46.6±0.6			0	2	115.9±1.0
45.9±0.9			6	5	114.6±1.6
44.1±1.0			5	6	111.4±1.8
42.3±0.2			0	7	108.1±0.4

degree centigrade by adding small quantities of hot water to the thermos jar. The humidity was controlled by means of about 10 ccs. of an appropriate acid-and-water mixture at the bottom of the boiling tube. As the itch mite is only 0.4 mms. long and yet is able, at a suitable temperature, to move as rapidly as two-and-a-half

centimetres a minute, and as it can climb a vertical glass surface without difficulty, a method of keeping the animals under control in such a way that they are easily recoverable was required. For the exposures lasting 10 minutes a gauze-bottomed tube was fitted inside the boiling tube with the gauze about one centimetre above the water-acid mixture. The mites were dropped into the tube clinging to a fragment of paper. A few were lost but the majority were recovered. For the 30-minute experiments, it was possible to use an apparatus which took a minute or two to heat up to the temperature of the air without prejudicing the accuracy of the observations. The apparatus consisted of a vulcanite ring approximately one centimetre in diameter and one millimetre in thickness, covered at the bottom with bolting silk. The mites were placed on the silk and then enclosed by placing a glass coverslip on top of the ring, which was already waxed; the glass "lid" being fixed by running a hot needle round the edge. The ring containing the mites was attached to a thread and was lowered down the tube to about a centimetre above the level of the acid.

At the end of each experiment the mites were examined under a microscope. Those that were dead could usually be distinguished by the characteristic appearance of the so-called "suckers" on the first two pairs of legs. In a living mite these are very difficult to see and never have the "text-book" sucker-like appearance so easily seen in killed mites. Furthermore, experiments have shown that any mites which were undamaged and which would burrow into the skin of volunteers, would crawl actively on a warm slide. There was seldom any doubt as to whether a mite was alive or dead, and we have counted as "dead" a small number of mites that moved feebly immediately after the experiment and died within the next few hours. The results are included in Table I. Experiments made with a 30-minute exposure show that the atmospheric humidity had no effect on the thermal death point, that is to say the animals were killed by the direct effects of heat before any adverse effects from desiccation could manifest themselves. A temperature of 49°C. (120°F.) appears to be fatal in 10 minutes and 47.5°C. (117.5°F.) in 30 minutes. Mites kept for 12 hours at 23°C. (73°F.), or at 13°C. (55°F.) had the same thermal death point as other individuals used immediately after their removal from a patient.

Survival Away from the Host.

Batches of mites were placed in vulcanite rings as described above and kept at different temperatures and humidities for varying periods. At the higher temperatures it was easy to distinguish between living and dead parasites but at the lower end of the scale (*i.e.* 5°C. (41°F.)) or below, the animals had to be warmed for several minutes before any activity was noticed. When starvation was the cause of death, as in these experiments, the "suckers" did not always take on the characteristic appearance noted after fatal exposure to heat or to a potent sarcopticidal medicament. In these circumstances it was felt that repeated warming and cooling might affect the results considerably, and each parasite was only used for one experiment at the lower temperatures.

The results are given in Table II. This shows that in warm conditions few mites survive as long as two days. In cool, moist conditions, survival may continue for as long as a fortnight, though towards the end of this period the surviving mites were probably too feeble to infect successfully. At 5°C. (41°F.) or at 0°C. (32°F.) the mites did not survive as long as at 13°C. (55°F.).

Phototaxis.

Sarcoptes appears to give neither positive nor negative phototactic reactions. When mites were placed in unidirectional light at any temperature sufficient to permit movement, their direction of progression bore no relation whatever to the direction of light. Light appeared neither to stimulate nor to inhibit movement for the animals were equally active at suitable temperatures in light or in darkness. In

nature *Sarcoptes* may exhibit a diurnal rhythm, being most active at night, when transmission usually occurs, but these experiments have no bearing on this point. Incidentally, the nocturnal itching characteristic of scabies is not directly connected with the mite's activity, as is often suggested.

TABLE II.

Percentage of ovigerous Females alive on successive Days after Extraction from Host.
(Figures in brackets indicate numbers of mites used in experiment.)

Conditions		1	2	3	4	5	6	7	8	9	10	11	12	13	14
°C.	% R.H.														
27.0-29.0	90	63 (35)	0 (12)	0 (8)											
21.0-24.5	90	84.7	30.5 (59 thorough out)	6.8	1.7	0									
24.0-25.0	30	63.5	6.8 (74 thorough out)	0											
12.0	90				0 (16)										
13.5-14.5	90	69.6	65.2 (23 thorough out)		60.9	52.2	34.8			30.4		26.1		8.7	4.3
12.0-13.5	30	75.0	28.8 (52 thorough out)	3.8	1.9	0									
5.0-6.0	90							78.6 (14)		20.0 (10)	14.3 (7)	0 (8)			
5.0-6.0	30							27.8 (18)		16.7 (18)	20.0 (10)		0 (10)		
0	Near saturation		100.0 (3)	40.0 (5)	20.0 (5)	20.0 (5)	25.0 (8)	33.3 (6)	28.6 (7)		0 (6)	0 (12)	0 (5)	0 (7)	0 (8)

Temperature Threshold for Movement.

At winter laboratory temperatures (14-15°C.) (57-59°F.), mites placed on a slide exhibited no movements. The threshold temperature for movement was discovered by placing the animals on a warm stage of a microscope and slightly raising or lowering the temperature. The threshold for movement was observed to be between 15 and 16°C. (48°F.) and no substantial difference was found where the mite was removed immediately from the host, where it had been kept at room temperature for several hours or where it had been kept in a state of chill coma at a temperature of 9°C. (48°F.) for 48 hours.

Although the animals could move at as low a temperature as 16°C. (61°F.), any movements they made were very slow, and they seldom progressed more than a millimetre or two. It was difficult to determine the exact position of the temperature at which more rapid movement started, but below 20°C. (68°F.) one could be certain of finding the mite within one centimetre of where it had been placed on re-examining the slide at the end of an hour. Above 20°C. much more rapid movement occurred, and unless kept in sealed containers mites were very easily lost.

Movements in a Temperature Gradient.

A simple temperature gradient was produced by having a very small and carefully shaded bunsen flame under a sheet of glass, the top of which was covered with graph paper. After about a quarter of an hour a steady temperature gradient, hottest in the centre and radiating outwards, was set up, and this did not fluctuate at any point more than 1°C. (1·8°F.) in an hour. The gradient was fairly steep, about 50°C. (122°F.) in the centre, falling to 27°C. (81°F.) at five centimetres and 22°C. (71·5°F.) at 10 centimetres. The animals moved quite rapidly, but as they seldom proceeded long in a straight line, and as their movements were somewhat erratic, it was difficult to determine accurately the rate of progression. In a large series of experiments in which the mites were started off at varying temperatures between 20 and 30°C., the following points were apparent:—(a) No simple thermotaxis exists in *Sarcoptes*. (b) The mites move on the whole towards the warmest part of the gradient, and those from below 24°C. (75°F.) always found their way to the hotter part of the scale, whereas those from higher temperatures never wandered down below 24°C. (c) All the mites were eventually killed by the heat as they made their way towards the hottest part of the gradient. Nothing in the nature of an “avoiding reaction” to high temperature appears to exist.

Discussion.

Experiments on the infectivity of blankets and clothing (Mellanby 1941–42) have suggested that the importance of these in the transmission of scabies has generally been overestimated. Nevertheless, infection by fomites does occasionally occur, and therefore disinfestation may sometimes be advisable. The figures given here indicate the nature of the temperatures necessary if heat sterilisation is performed. Provided that the whole of the material reaches 50°C. (122°F.) for 10 minutes *Sarcoptes* will be exterminated.

The reactions of the animals to temperature may be of importance when considering how transmission takes place. Although at a suitable temperature (*i.e.* on the surface of the skin) *Sarcoptes* can move at a fairly high speed, so little movement takes place below 20°C. that it would be impossible for the animals to move from one bed to another. Again the avoidance of temperatures below 24°C. will generally be sufficient to keep the parasites on the surface of the skin and to discourage them from walking on to fomites. This helps to account for the ease with which the disease can be transmitted by direct personal contact, as compared with indirect means of transmission.

Practically the only work which has been done previously on the biology of *Sarcoptes* is that of Munro (1919), and his experiments suggest that the thermal death point is materially higher than our figures, and that humidity greatly affects the result. Our findings are in conformity with more recent work on a variety of other Arthropods.

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Summary.

(1) Adult female *Sarcoptes* were killed by 49°C. (120°F.) in 10 minutes and by 47·5°C. (117·5°F.) in 30 minutes.

(2) At 28°C. (82°F.) no *Sarcoptes* survived for two days and the majority died in 24 hours.

(3) At 13°C. (55°F.) and 90 per cent. R.H. the majority of the mites died within a week, but a few survived longer, even up to 14 days.

(4) At temperatures below 13°C. (55°F.) the mites survived for a shorter time.

- (5) *Sarcoptes* gives no reactions, positive or negative to unidirectional light.
- (6) Below 15°C. (59°F.) *Sarcoptes* is in chill coma. Little movement occurs below 20°C. (68°F.).
- (7) In temperature gradient mites seldom, if ever, go below 24°C. (75°F.). They will walk into high temperatures which prove rapidly lethal.

References.

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