The effect of changes in the osmotic pressure upon *Hammerschmidtiiella diesingi* (Hammerschmidt, 1838) with reference to the survival of the nematode during moultng of the cockroach

**By D. L. Lee**

*Molteno Institute, University of Cambridge*

(Received 21 July 1959)

It was observed that *Leidynema appendiculata* (Leidy, 1850) and *Hammerschmidtiiella diesingi* (Hammerschmidt, 1838; Chitwood, 1932), which are nematodes parasitic in the hind-gut of *Blatta orientalis* L., could survive in the hind-gut when the cockroach moulted and it was decided to see what effect moulting of the cockroach had upon the nematodes.

In moulting cockroaches there is a certain amount of drying in the gut which presumably increases the osmotic pressure of the gut contents. The nematodes in moulting cockroaches are found inside the cast peritrophic membrane of the gut, have a shrunken appearance and are rather inactive. By examining the nematodes at various times after the insects had moulted it was found that the cast peritrophic membrane becomes broken up in the middle section of the hind-gut. The nematodes, which have at this stage become more active, escape from the broken membrane and move up to their normal position in the hind-gut.

The shrunken appearance of the nematodes suggested that they were in a hyper-tonic environment. It was therefore decided to observe the effect of various concentrations of 1·0 M sodium chloride, 1·0 M sucrose, and sea water upon the adult female nematodes to determine if they were capable of surviving long exposures to these solutions and to see if there was subsequent recovery in isotonic solutions.

**METHOD**

Adult females of *Hammerschmidtiiella diesingi* were used in the following experiments because they are not so active as *Leidynema appendiculata* and were therefore easier to measure.

The nematodes were taken from adult *Blatta orientalis* and immersed in the experimental solutions in solid watch-glasses. The watch-glasses were filled to the brim with the solution, covered with a glass plate and incubated at 24° C. The edges were sealed with petroleum jelly to prevent evaporation and so keep the osmotic pressure of the solution constant during the experiment. The nematodes were observed under a dissecting microscope and measurements made of their length, without removing them from the watch-glasses. Measurements were made by twisting thread along the length of a camera lucida image of the nematode.
D. L. LEE
to determine the increase or decrease in length (Stephenson, 1942). Because of
their undulating movements and small size, this was the only method which
could be used to determine the effect of the experimental solutions on the nem-
todes. Each experiment was carried out upon five individuals and a mean was
taken. The solutions used were various dilutions of 1·0 M sodium chloride, 1·0 M
sucrose, and sea water.

Dead nematodes were easily noticed as they very quickly showed signs of decay.

RESULTS

The effect of immersion of adult females of *Hammerschmidtella diesingi* in
various dilutions of 1·0 M sodium chloride, 1·0 M sucrose and sea water, for certain
periods of time, are shown in Figs. 1–3. It was found that the rate and extent of
increase or decrease in length varied with the strength of the solution employed.
After 2–3 hr. in hypertonic sodium chloride solutions there was a reduction in the
amount of shrinkage, the recovery being more rapid, at first, in the more con-
centrated solutions (Fig. 1). After 6 hr. in 0·2 M sodium chloride the nematodes had
regained their normal length (Fig. 1), whereas it took nematodes in 0·3 M sodium
chloride up to 24 hr. to regain their original length and even longer for those in
0·5 M sodium chloride. The nematodes in 0·2 and 0·3 M sodium chloride were still
alive after 24 hr. but most of those in 0·5 M were dead. In 0·05 and 0·08 M sodium

![Fig. 1. The percentage increase or decrease in length of females of *Hammerschmidtella diesingi* in distilled water and in various molar concentrations of sodium chloride (NaCl). A = distilled water; B = 0·05 M-NaCl; C = 0·08 M-NaCl; D = 0·15 M-
NaCl; E = 0·2 M-NaCl; F = 0·3 M-NaCl; G = 0·5 M-NaCl.](https://www.cambridge.org/core/asset/6031182000025324)
Hammerschmidtiella diesingi

chloride there was some recovery towards the normal length (Fig. 1) but the nematodes had not regained their original length within 24 hr., although they were still alive. The smallest changes in length occurred in 0-15 m sodium chloride which must be approximately isotonic (Fig. 1). Similarly, nematodes placed in hypertonic solutions of sea water recovered their normal length after a period of shrinkage (Fig. 3), whereas there was little recovery in hypotonic solutions. It

Fig. 2. The percentage decrease in length of females of *Hammerschmidtiella diesingi* in 0-4 m (A) and 0-6 m (B) sucrose.

Fig. 3. The percentage increase (+) or decrease (−) in length of females of *Hammerschmidtiella diesingi* in various dilutions of sea water. A = 12%; B = 30%; C = 50% sea water.

was found that 30% sea water was isotonic (Fig. 3). However, nematodes placed in hypertonic sucrose solutions (Fig. 2) continued to shrink and no reduction in the amount of shrinkage occurred within 24 hr.

Nematodes which had regained their normal length after 24 hr., or less, in 0-2 and 0-3 m sodium chloride, increased in length, as if they were in a hypotonic

16-2
solution, when placed in normally isotonic sodium chloride (0·15 M) (Fig. 4) or 30% sea water. Similarly, it was found that females of *H. diesingi*, taken from the hind-gut of a moulting cockroach and placed in 0·15 M sodium chloride, increased in length as if they were in a hypotonic solution (Fig. 4). This increase in length of the nematodes taken from moulting cockroaches and placed in 0·15 M sodium chloride is approximately the same as in those nematodes taken from 0·4 M sodium chloride, after they had regained their normal length, and placed in 0·15 M sodium chloride (Fig. 4).

**DISCUSSION**

It has been shown by Hobson, Stephenson & Beadle (1952) and Hobson, Stephenson & Eden (1952) that the osmotic pressure, conductivity and chloride concentration of the body fluid of *Ascaris lumbricoides* were almost in direct proportion to those of the external medium used in their experiments (20–40% sea water) and that this nematode is nearly poikilosmotic under these conditions. Mueller (1929) has demonstrated that certain non-electrolytes can pass through the body wall of *Ascaris*.

The experiments of Pannikar & Sproston (1941) with *Angusticaecum* sp., an ascarid from a turtle, indicated a permeability to sodium chloride. Although the nematode lost and gained salts in relation to the salts of the medium, it could remain hypertonic to tap water.

Stephenson (1942) showed that water can pass both into and out of the body of *Rhabditis terrestris*, under the influence of osmotic forces, with a resulting increase or decrease in the size of the body. He also found that after prolonged immersion of *R. terrestris* in distilled water, the swelling of the body was reduced and there was a return to normal movement. He suggested that this recovery was due to the existence of an active method of osmotic regulation as recovery was inhibited by injury or when cyanide was present. *H. diesingi* rapidly expands and ruptures when placed in distilled water; however, in 12% sea water, 0·05 and 0·08 M sodium chloride there is no marked decrease in the initial swelling after 24 hr. although the nematodes are still alive. This seems to suggest that the active method of osmotic regulation found in *R. terrestris* is either absent or works much more slowly in *H. diesingi*. Stephenson also found that when *R. terrestris* was immersed in hypertonic solutions there was an increase in the internal osmotic pressure, largely due to the removal of water from the body, and that after a considerable time, about 20 hr., there was a reduction in the amount of shrinkage. A similar phenomenon has been observed in *H. diesingi* immersed in hypertonic sea water and sodium chloride solutions, there being complete recovery in length after 6 hr. in 0·2 M sodium chloride, and after 24 hr. in 0·3 M sodium chloride and in 50% sea water. When nematodes which have recovered their original length in a hypertonic solution are placed in 30% sea water or 0·15 M sodium chloride, both of which are normally isotonic, there is an increase in length as if the worms were in a hypotonic solution. This seems to suggest that the nematodes immersed in hypertonic sodium chloride solutions have, after a period of shrinkage due to water loss, taken up ions from the surrounding medium,
Hamerschmidtia diesingi thereby increasing the osmotic pressure of the body fluid, and so taken up water from the medium with a resulting decrease in the amount of shrinkage. These nematodes were unable to recover their normal length within 24 hr. when transferred to a normally isotonic solution which suggests that the excretion of ions from the body fluid does not take place as readily as the uptake of ions. It has been shown that nematodes taken from moulting cockroaches increase in length in 0·15 M sodium chloride, indicating that they have taken up ions from the contents of the hind-gut. There must eventually be a return to the normal length in isotonic media otherwise the nematodes would become more distended after each moult of the cockroach. The increase in length, in 0·15 M sodium chloride, of nematodes taken from moulting cockroaches is approximately the same as the increase in length of nematodes taken from 0·4 M sodium chloride, after they had regained their original length, and placed in 0·15 M sodium chloride (Fig. 4). This does not necessarily signify that the hind-gut contents of moulting cockroaches have an osmotic pressure equivalent to 0·4 M sodium chloride because a certain amount of shrinkage may be caused by other factors.

The variations in length of the nematode inside the moulting cockroach, where changes in the osmotic pressure presumably occur gradually, will not be as great as in the experiments described above where the worms were suddenly transferred from one solution to another of quite different osmotic pressure.

These experiments show that females of *H. diesingi* can survive changes in the osmotic pressure of the external medium and this will help them to survive any osmotic changes which may occur in the hind-gut of the moulting cockroach.

**SUMMARY**

Females of *Hamerschmidtia diesingi* can survive in the hind-gut of moulting *Blatta orientalis*. After a period of shrinkage they recover their normal length within 24 hr. in 0·2 and 0·3 M sodium chloride and in 50 % sea water, but not in hypotonic media or in hypertonic sucrose. Females of *H. diesingi*, which have regained their original length in hypertonic media, swell when placed in normally isotonic media; a similar phenomenon occurs with nematodes taken from moulting cockroaches.

I wish to thank Dr P. Tate for his advice and encouragement during this investigation.

**REFERENCES**


