THE RISE AND FALL OF IMMUNITY TO *TRICHINELLA SPIRALIS* IN THE ALBINO RAT AND ITS EFFECTS ON GROWTH AND REPRODUCTION OF THE PARASITE

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Immunity acquired against *Trichinella spiralis* through recovery from a previous infection in experimental animals has been demonstrated by Ducas (1921), McCoy (1931-1932), Bachman and Oliver-Gonzalez (1936), Roth (1939), Fischthal (1943), and others. These reports show that many of the larvae are eliminated before reaching maturity and that fewer larvae of the next generation reach the muscles in immune animals than in the animals which were not previously immunized. Fischthal (1943) shows that little or no immunity is produced in the rat within seven days after feeding the *Trichinellae* larvae. Rappaport and Wells (1949) were unable to show any reduction in the adult worm yield in mice reinfected ten days after the initial infection; however, after thirty-five days and one hundred days the yield of adult worms was lower, and adults of both male and female were smaller than those in the control mice.

It is apparent that the immunity produced is effective against the intestinal phase of the parasite. This study was conducted to determine the effects of the immunity upon the size and the reproductive powers of the female *Trichinella spiralis*.

Methods

Three groups of six rats each were fed one gram of muscle heavily infested with *Trichinella spiralis*. The muscle was previously examined microscopically to ascertain the degree of infestation and to assure that all rats were receiving approximately the same number of *Trichinellae* larvae. The animals of each group were given a challenging dose of larvae (two grams of muscle each) at twenty days, thirty days, and fifty-four days, respectively, after the initial infection. A fourth group was given a similar dose, and served as the control group.

Two rats from each group were sacrificed two days, five days, and seven days, respectively, following the challenging dose. The adult females were removed from the intestine and counter-stained whole mounts were made. Each female was measured with the aid of an occular micrometer. The eggs and larvae within the uterus of the females were counted by optical sectioning.

The albino rats, used in this study, were of both sexes and were three months old at the start of the experiment.

Results

A comparison of adult *Trichinellae*, recovered from reinfected and

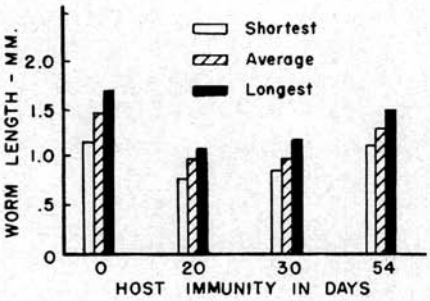

Fig. 1.—Two-day-old worms recovered from the intestines of controls and immune albino rats.

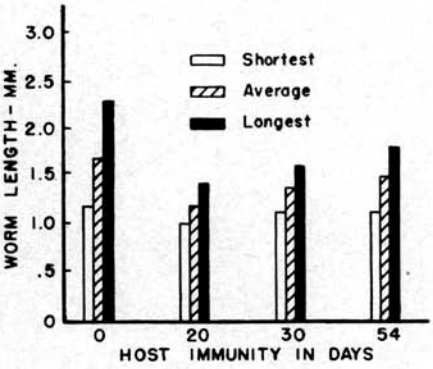

Fig. 2.—Five-day-old worms recovered from intestines of controls and immune albino rats.

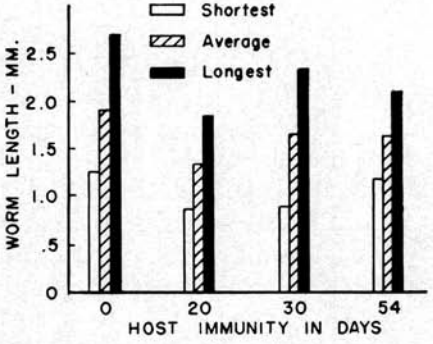

Fig. 3.—Seven-day-old worms recovered from intestines of controls and immune albino rats.

control rats, demonstrates that the immunity produced is effective against the intestinal phase.

Figures 1, 2, and 3 show the lengths of the female worms removed two, five, and seven days, respectively, after the challenging dose had been administered. Two-day-old worms (fig. 1) removed from rats immunized for twenty days averaged 0.95 mm; those from animals immunized for thirty days averaged 0.97 mm; those from animals immunized for fifty-four days averaged 1.32 mm; and those from the controls averaged 1.42 mm. Five-day-old worms (fig. 2) removed from rats immunized for twenty days averaged 1.16 mm; those from animals immunized for thirty days averaged 1.34 mm; those from animals immunized for fifty-four days averaged 1.44 mm; and those from controls averaged 1.68 mm. Seven-day-old worms (fig. 3) removed from rats immunized for twenty days averaged 1.35 mm; those from animals immunized for thirty days averaged 1.67 mm; those from animals immunized for fifty-four days averaged 1.66 mm; and those from the control averaged 1.9 mm.

Figures 4, 5, and 6 show the number of eggs and larvae within the uterus of the female worms, removed two, five, and seven days, respectively, after the challenging dose had been administered. In the two-day-old worms (fig. 4) removed from rats immunized for twenty days, the range of the egg-larvae count was 40 to 100 with an average of 65; from animals immunized for thirty days, the range was 48 to 110 with an average of 76; from animals immunized for fifty-four days, the range was 62 to 115 with an average

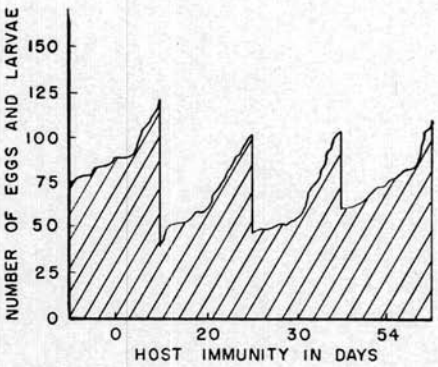

Fig. 4.—Two-day-old worms recovered from intestines of controls and immune albino rats.

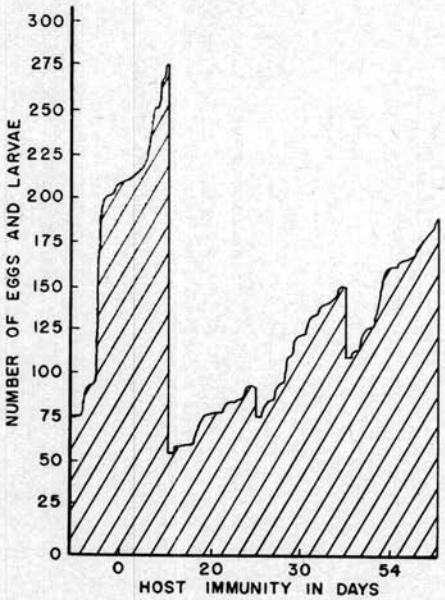

Fig. 5.—Five-day-old worms recovered from intestines of controls and immune albino rats.

of 81; and from the control, the range was 75 to 125 with an average of 92. In the five-day-old worms (fig. 5) removed from rats immunized for twenty days the range of egg-larvae count was 52 to 90 with an average of 68; from animals immunized for thirty days the range was 69 to 140 with an average of 112; from animals immunized for fifty-four days the range was 108 to 177 with an average of 148; from the controls the range was 75 to 275 with an average of 175. In the seven-day-old worms (fig. 6) removed from rats immunized for twenty days, the range of egg-larvae count was 38 to 193 with an average of 115; from animals immunized for thirty days, the range was 55 to 243 with an average of 149; from animals immunized for fifty-four days, the range was 51 to 225 with an average of 138; from the control, the range was 110 to 285 with an average of 199.

Discussion

McCoy (1931) was able to demonstrate in rats, following infection with *Trichinella spiralis,* a marked

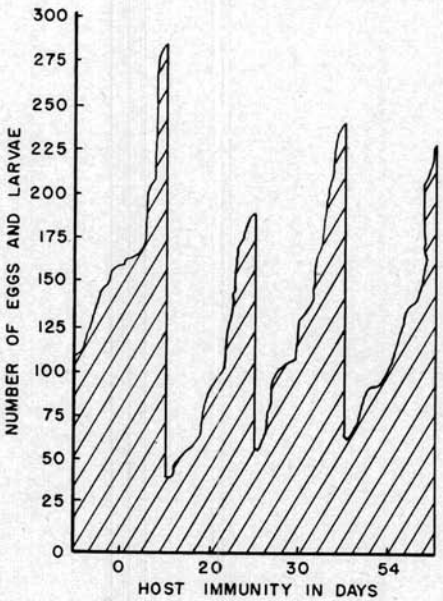

Fig. 6.—Seven-day-old worms recovered from intestines of controls and immune albino rats.

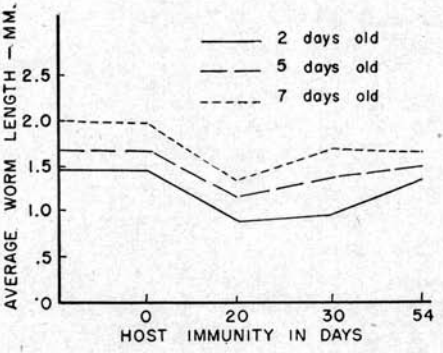

Fig. 7.—Average lengths of worms which were two, five, and seven days of age.

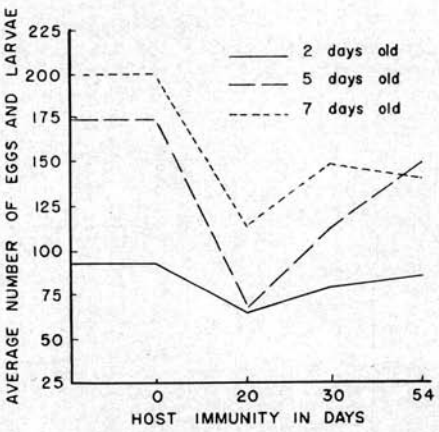

Fig. 8.—Average number of eggs and larvae in the uterus of female worms, two, five, and seven days of age.

immunity to subsequent infection of the parasite. His animals were able to withstand twice the lethal dose for noninfected control animals. McCoy (1940) found a rapid loss of larvae from the intestines of immune rats a few hours after feeding, and concluded that the resistance is chiefly mechanical or allergic in that the sensitized mucosa in immune animals secretes an increased amount of mucus, which with peristalsis effects rapid expulsion of the helminths. Chandler (1939) maintains that the *Trichinellae* induces within the host two distinct phases of immunity; namely, (1) a relatively weak general parenteral immunity, and (2) a relatively strong local intestinal immunity. Taliaferro (1940) holds that antibodies are involved in the local intestinal phase of reaction against the adult helminths.

In this work no attempt was made to study the rate and magnitude of the expulsion of the *Trichinellae* from the intestine, as so many of the workers have concurred with McCoy. The purpose of this investigation was to study the effects of immunity upon g r o w t h and reproductive powers of the female *Trichinella spiralis*. In this study, one group of animals was given a challenging dose of larvae twenty days after infection, as this is the approximate time when larvae are at their peak within the circulatory system; the second group was given a challenging dose on the thirtieth day, as at this time muscle invasion has reached or passed its peak; and the third group was given the challenging dose on the fifty-fourth day, as at this time the capsule is well established.

A study of figures 1, 2, 3, and 7, reveals the effects of immunity on growth of the female *Trichinellae*. In all three of the experimental groups the growth is very much inhibited. The inhibition (fig. 7) is greatest in those animals which were immunized for twenty days and least in those immunized for fifty-four days. This indicates a marked rise in immunity up to twenty days, which is the time when the larvae of the next generation are in the migratory stage. Females removed from

animals immunized for thirty days are larger than those removed from animals immunized for twenty days. This would indicate a fall in immunity at the time muscle invasion is at its height. This fall in immunity continues, as is evidenced by the fact the females removed from animals immunized for fifty-four days are slightly larger than those developing in the thirty-day immunized animals. However, the immunity still persists, since the worms are considerably smaller than those removed from animals which had not been previously immunized. The indication is that immunity continues to wane gradually for a period of time, which is in accord with Roth (1939) who demonstrated intestinal immunity in the guinea pig one and three fourth years after the first infection.

A study of figures 4, 5, 6, and 8, reveals the effects of immunity on the reproductive powers of the female *Trichinella spiralis*. In all three of the experimental groups, the production of eggs is very much inhibited. The inhibition (fig. 8) is greatest in those animals which were immunized for twenty days and least in those immunized for fifty-four days. This also indicates a marked rise in immunity up to twenty days, which is the time when the larvae of the next generation are in the migratory stage. There was a greater number of egg-larvae in females removed from animals immunized for thirty days than in those removed from animals immunized for twenty days. This likewise indicates a fall in immunity at the time muscle invasion is at its height. The fall of immunity continues as is evidenced by the fact that the females removed from animals immunized for fifty-four days contained a greater number of eggs and larvae than those developing in the thirty-day immunized animals. Furthermore, figure 8 shows that the immunity still persists, since the egg-larvae count is much smaller than in those females removed from animals which had not been previously immunized, but it continues to wane gradually.

The works of Fischthal (1943) and Rappaport and Wells (1949) demonstrate little or no immunity produced within seven to ten days following the initial feeding. However, Fischthal (1943) showed that a small dose of *Trichinellae* larvae is capable of producing immunity and that a period of approximately fourteen days is adequate to develop this immunity. It should be emphasized that the larvae are now in the migratory stage. It is the opinion of the writers that these results further substantiate the work of Taliaferro (1940) that antibodies are involved in the local intestinal phase of reaction against adult *Trichinella spiralis*.

Summary

1. *Trichinella spiralis* developing to maturity in the intestinal tract of the albino rat stimulates a persistent partial immunity which rises rapidly and then falls to a lower degree of effectiveness.

2. The degree of immunity or resistance to the parasite was determined by studying its effects upon growth and reproductive powers of the female *Trichinella spiralis*.

3. Adult female *Trichinellae* recovered from the intestines of immune rats are significantly smaller

than those taken from the intestinal tract of rats not previously immunized.

4. Females developing in immune rats contained fewer eggs and larvae in the uterus than those developing in the controls.

5. It was demonstrated that the immune mechanism in the host has an inhibiting effect upon the physiological activities which influence growth and reproduction.

6. The immunity is greatest during the migratory stage of the *Trichinellae* larvae, and declines when muscle invasion is at its height.

7. Immunity still persists at fifty-four days after the initial infection, but is gradually declining.

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