INCREASE OF RATE OF EGG PRODUCTION WITH GROWTH IN SOME INTESTINAL NEMATODES OF SHEEP AND HORSES*

L. H. RACTLIFFE and L. F. LEJAMBRE
New York State Veterinary College, Cornell University, Ithaca, N.Y. 14850, U.S.A.
(Received 13 January 1971)

Abstract
RACTLLFFE L. H. & LEJAMBRE L. F. 1971. Increase of rate of egg production with growth in some intestinal nematodes of sheep and horses. International Journal for Parasitology, 1: 153-156. There is a positive relationship between the number of uterine eggs and size of worm in Chabertia ovina, Haemonchus contortus, Oesophagostomum columbianum, and Parascaris equorum, and a linear relationship between the weight of the egg sac and the weight of the remainder of the worm in Oxyuris equi. These relationships imply that the rate of egg production increases with growth. Consequently it would be expected that (a) the total egg output of a population of parasites would be more closely related to the total weight of the worms than to their number and (b) there would be a logarithmic increase with time in the egg output of a newly infected host even if the increase in the number of worms harbored by the host were only linear with time.

INDEX KEY WORDS: Chabertia ovina; Haemonchus contortus; Oesophagostomum columbianum; Parascaris equorum; Oxyuris equi; rate of egg production; sheep; horses.

It has been observed that the variation in the egg output of grazing animals infected with intestinal nematodes is not necessarily related to the variation in the numbers of worms harbored (see review by Michel, 1969). This has been interpreted as evidence that the regulation of egg production is autonomous, that is, independent of changes which may occur in the worm burden. However, we believe that the number of worms often provides a poor measure of the size of the worm burden simply because worms may differ greatly in size. The purpose of this paper is to provide evidence supporting the hypothesis that the rate of egg production increases with the size of the nematode and consequently to formulate a hypothesis relating the variation in the total egg output of an infected animal with the variation in the size of its worm burden.

MATERIALS AND METHODS
The following parasites of sheep and horse were studied: Chabertia ovina, Haemonchus contortus, Oesophagostomum columbianum, Oxyuris equi, Parascaris equorum. In the case of each species worms were collected from single host animals. They were carefully dried with tissue paper and then weighed individually while still alive except in the case of H. contortus worms which were weighed in groups consisting of worms of similar lengths. After weighing, the uteri were dissected out, broken in 0.09% saline and, except in the case of O. equi and P. equorum, the number of eggs which they contained estimated by making counts of random samples. Differences among the numbers of eggs in the uteri of P. equorum worms and in the uteri and egg sacs of O. equi worms were estimated by weighing.

RESULTS
The results are displayed graphically in Figs. 1-5. The lines drawn on these figures represent the equation

$$y = \beta_0 + \beta_1 x + \beta_2 x^2$$

* This work was supported by the State of New York and by the National Institute of Health (grant numbers NIH-GM-05900-12 and ST01ES00130-03).
I.J.P. VOL. 1. 1971  EGG PRODUCTION IN INTESTINAL NEMATODES  155

FIG. 4

PARASCARIS EQUORUM

wt. of eggs and uterus, g

wt., g

Fig. 4

FIG. 5

OXYURIS EQUI

wt. of eggs, eggs sac and uterus, mg

wt., mg

Fig. 5

Figs. 1–5. Regressions of numbers or weights of eggs on weights of worms.

\( \beta_0, \beta_1 \) and \( \beta_2 \) are the estimates computed for each species by the method of least squares; the quadratic term is only used in those cases when its inclusion in the regression leads to an improvement significant at the 1% probability level. The lines are intended as visual aids only and no special significance is attributed to them.

DISCUSSION

Consider first \( C. ovina, H. contortus, O. columbianum \) and \( P. equorum \) (Figs. 1–4). It can be seen that there is a relationship between the number of uterine eggs and the weight of the worm. There may be some question as to whether the relationship is linear or non-linear (and these questions could probably be resolved and the relationships tightened by collecting worms of wider size ranges from different host individuals) but there is indisputably a positive relationship. As some maturation processes have to occur before the egg is released from the uterus it is reasonable to assume that the mean time an egg spends in the uterus is
constant for each species. It follows from this assumption that the rate of egg production is linearly related to the number of eggs contained in the uterus. We conclude, therefore, that as a worm of one of these species grows, its rate of egg production increases.

The case of *O. equi* (Fig. 5) is somewhat different because in this case we have counted all the eggs which the worm has ever produced. The relationship of the weight of the egg to the weight of the remainder of the worm appears to be linear. Now if the rate of egg production were not to increase as the worm grew then the relationship would not be linear and the regression curve would be concave to the X-axis. We can conclude, therefore, that the rate of egg production increases with growth in this species as well.

Michel (1963) comparing *Ostertagia ostertagi* from different calves showed that there was a correlation between the mean length of female worms and the mean number of eggs in their uteri. This could be interpreted as evidence for an allometric relationship between size and rate of egg production although Michel himself does not appear to do so.

An allometric relationship between rate of egg production and growth is relevant to attempts at relating the rate of egg output of a population of parasites with the size of that population. Clearly one would expect fecal egg counts to be more closely related to the total weight of parasites in a host than to their total number.

Such a relationship also has bearing on the logarithmic increase in the egg output of sheep infected with intestinal nematodes discussed by Crofton (1963) and by Michel (1969). Crofton postulated that the logarithmic increase is the result of a build-up of several generations of parasites, the contribution of each generation being geometrically related to that of the previous generation. Michel observed that the apparent logarithmic increase can occur under conditions where only one or at most two generations could possibly be involved and suggests that the increase is, in fact, not logarithmic but linear. Our own observations, which will be published elsewhere, support Michel's argument in as much as they show that only one generation may be involved during a period of apparent logarithmic increase (although they also indicate that several generations are involved in the whole epidemic). However, even in such cases, in which the increase in number of parasites in the host is presumably linear with time, one would still expect a logarithmic increase in the total egg output simply because of the growth of the parasite individuals, growth itself being a logarithmic process.

REFERENCES

