REGENERATION OF FEATHERS AFTER THYROID FEEDING

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(*Received December* 5, 1935)

(With Five Text-figures)

INTRODUCTION

Studies of the regeneration of feathers after plucking show the existence of considerable differences in the time intervals before the commencement of regeneration in individual feathers.

In normal moulting, the development of the new feather starts before the old feather is shed, and as growth of the new feather continues and it emerges from the follicle, it may frequently be seen projecting within the inferior umbilicus of its predecessor (Hosker, 1935). Experimental moulting (*e.g.* by thyroid feeding in excessive doses) merely causes an acceleration of this process. When, as is often necessary in assaying the effect of endocrine extracts upon plumage, whole areas are plucked in order to ascertain that the feathers will be in an actively growing condition when the extract is administered, it often happens that many feathers fail to regenerate at all. If near the normal moulting period when plucked, the new feathers usually regenerate immediately (the "pin feathers" showing within the first week), but at other seasons of the year regeneration may be delayed for months.

It was decided, therefore, to examine the effect of some known accelerating substance on the rate of regeneration of plucked feathers, and also to compare the histological picture of feather germs which regenerated rapidly with those which had failed to regenerate for some time after plucking.

MATERIAL AND METHODS

Three groups of Rhode Island Red fowls were used:

(1) Seven birds aged 10 months were divided into three groups—three (1 ♂ and 2 ♀♀) receiving 30 gm. thyroid and two (1 ♂ and 1 ♀) 30 gm. liver 1 day after plucking, the remaining two (1 ♂ and 1 ♀) acting as blank controls. Regenerating feathers were measured at 2-day intervals for 1 month.

(2) Fourteen birds aged 6 weeks were divided into three groups—four receiving 4 gm. thyroid and five receiving 4 gm. liver 4 days after plucking, the remaining five acting as blank controls. Regenerating feathers were measured daily for 1 month.

(3) Twenty-nine birds aged 8 weeks were divided into three groups—nine receiving 4 gm. thyroid and nine receiving 4 gm. liver 2 days after plucking, the remaining eleven acting as blank controls. Regenerating feathers were measured at 4-day intervals for 3 weeks.

In each case, the birds had ten feathers plucked from each of the following areas —neck, anterior back, posterior back, thigh, anterior breast, posterior breast, abdomen. The area was ringed and the feathers round the plucked area clipped to ensure correct identification. Desiccated thyroid (Boots) or dried liver prepared in the laboratory from fresh tissue, was made up into pellets with equal quantities of flour. These were fed to the bird by hand and in one dose, the pellets being pushed down the gullet into the crop. For the histological examination of the feather follicles, birds which showed retarded regeneration were killed, the skin fixed in alcoholic Bouin's solution, imbedded in celloidin and wax, cut at 6–8μ, stained by the short method of iron haematoxylin and counter-stained with picro-fuchsin.

EFFECTS OF THYROID AND LIVER FEEDING

The general effects of thyroid feeding upon the plumage of the fowl may briefly be summarised as follows:

(*a*) Excessive doses given once only, cause moulting and depigmentation of newly regenerated feathers (Giacomini, 1924; Krizenecky, 1926; Podhradsky, 1926; Zawadowsky, 1925).

(*b*) Small doses over long periods cause accelerated feathering; weakening of the parts of the feather, and also approximation towards the henny type in cockerels (Danforth, 1933; Domm, 1929; Krizenecky and Nevalonnyj, 1927; Torrey and Horning, 1925).

(*c*) Single injections cause a pigmented bar (Juhn and Barnes, 1931; Lillie and Juhn, 1932).

(*d*) Repeated injections or feeding with desiccated thyroid cause intense melanisation (Cole and Reid, 1924).

(1) *Mature birds*

(*a*) *General effects.* The doses employed in the present experiments were of the first order (*i.e.* excessive), and in the mature birds moulting began at the end of the first week after feeding thyroid, being more extensive in the females than in the males. Podhradsky (1926) found intensity of moulting dependent on the quantity of thyroid used and not on the sex of the bird. In the present experiment, only one male and two females were used, the latter being considerably lighter in weight than the male received a larger dose of thyroid per kilogram of body weight. They cannot therefore be said to refute Podhradsky's statement.

Fig. 1 illustrates the correlation existing between the weights of the birds and feather growth. The weights of the liver-fed birds and the blank controls remained fairly constant, the slight loss in weight being undoubtedly caused by the intense cold and snow which prevented the usual easy access to food. In the thyroid-fed birds, a decided decrease in weight was observed for 2 weeks, during which period

moulting occurred and the birds showed the usual signs of emaciation and irritability common in hyperthyroidism, and laying ceased. New feather growth was rapid during the following fortnight, and the weights returned to normal. In the females, the new feathers were almost completely white but in the males were only tipped with white, the basal part showing increased melanisation. The feathers regenerated were quite normal except for colouring, and in the male approximated towards the henny type. The plucked feathers regenerated at approximately the same time as the moulted ones, despite the period elapsing between plucking and moulting. This is presumably due to the fact that in the former case the papilla must

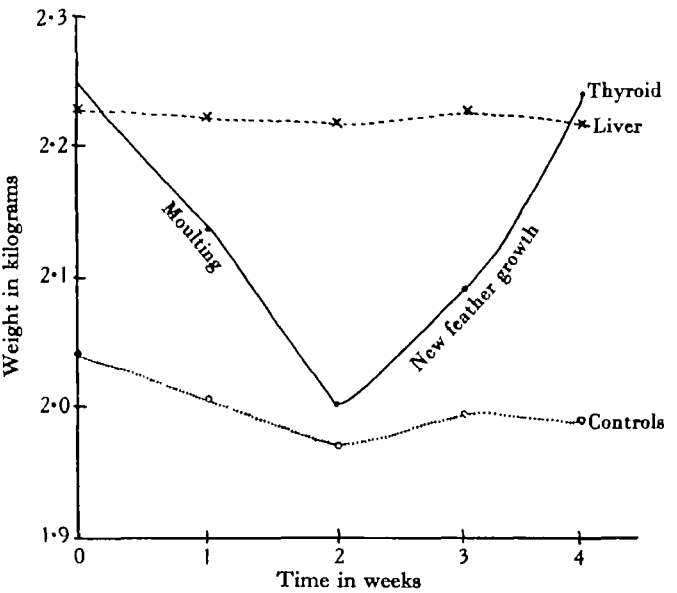

Fig. 1. Graph showing the effect of thyroid and liver feeding on the weights and feather growth of mature fowls.

heal and regenerate before a new feather can be formed, whereas moulting causes no injury to the papilla.

(*b*) *Number of feathers regenerated.* Before considering the rate of growth of the feathers regenerated, it is necessary to consider the actual number of feathers regenerated. In the thyroid-fed birds in all cases, there was 100 per cent. regeneration regardless of sex or area plucked; in the liver-fed birds, 59 per cent. regeneration, and in the blank controls only 35 per cent. regeneration. This is illustrated in tabular form in Fig. 2. Taking sex into consideration, the male bird in both liver-fed birds and blank controls had a higher percentage regeneration than the females. An analysis of the percentage regeneration taking areas into consideration, shows 17 per cent. in the abdominal area of liver-fed birds to 80 per cent. in the thigh area, 20 per cent. in the neck area of blank controls to 70 per cent. in the posterior breast area, as against 100 per cent. in all areas of thyroid-fed birds. It is obvious, therefore, that thyroid feeding has a definite influence in the number of feathers

regenerated; and it seems probable that liver affects this also, though to a less marked extent.

(*c*) *Rate of growth.* The graphs of feather growth for each area plucked (Fig. 3) show the very much more rapid growth of feathers in thyroid-fed birds compared with liver-fed or blank controls, assuming firstly that each feather plucked is capable of regeneration, and secondly, taking into account the actual number of feathers regenerated. In the latter case, although the difference between the rates of growth of feathers in thyroid fed birds compared with liver fed or controls is reduced, it is still very marked. It is a moot point whether liver has any direct accelerating effect on feather growth as is indicated for the graph for the thigh area, as this effect is not constant in posterior back and posterior breast feathers. In the abdominal region,

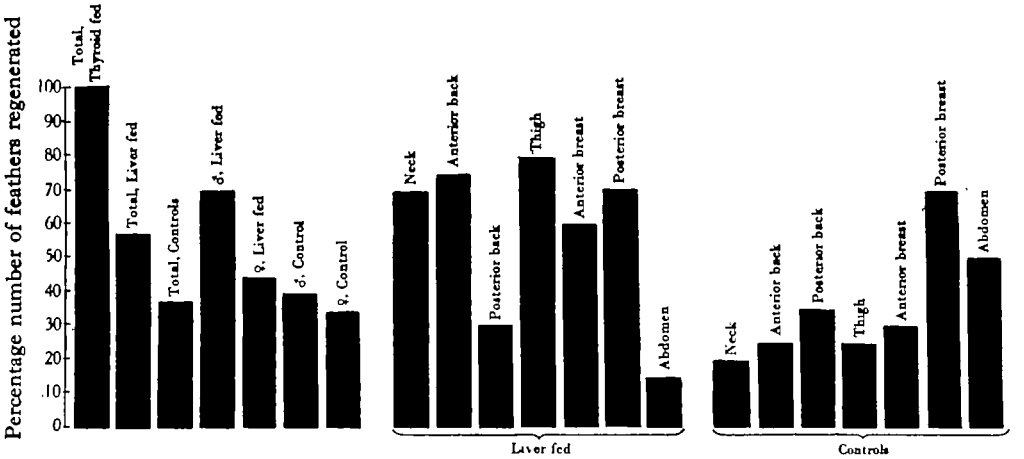

Fig. 2. Table showing percentage number of feathers regenerated in mature Rhode Island Red fowls within 32 days after plucking, and after feeding large doses of thyroid or liver as compared with blank controls.

too, the feathers of the blank controls regenerated more rapidly than those of the liver-fed birds.

(2) *Young birds*

In young birds receiving an equal dose of thyroid (per gram of body weight) to the older birds, loss of weight does not follow. The average increase in weight in this growing stock, however, is much smaller in the thyroid-fed birds than in the liver-fed or blank controls (4, 10 and 12 per cent. respectively in group C). As moulting is a continuous process in growing fowls, thyroid feeding merely accelerates this, and feathers from any region of the body are tipped with white or bear white bars according to the stage of their growth at the time of feeding. The plucked feathers which regenerated were never completely white, but invariably had white tips, usually followed by a black bar.

The average measurements of regenerating feathers in group B show that, as in group A, the rate of growth of feathers in thyroid-fed birds far exceeds that in liver-fed or blank controls. But in this group, the posterior breast and neck feathers

regenerated more rapidly in the blank controls than after liver feeding. Considering all the feathers regenerated in each area, regardless of treatment, in these young birds the rate of growth was most rapid in thigh feathers, followed by posterior back, posterior breast, neck, anterior back, anterior breast and abdomen—a very different order from that existing in the mature birds (group A), where the rate of growth was most rapid in the posterior breast feathers, followed by thigh, anterior back, anterior breast, neck, posterior back and abdomen.

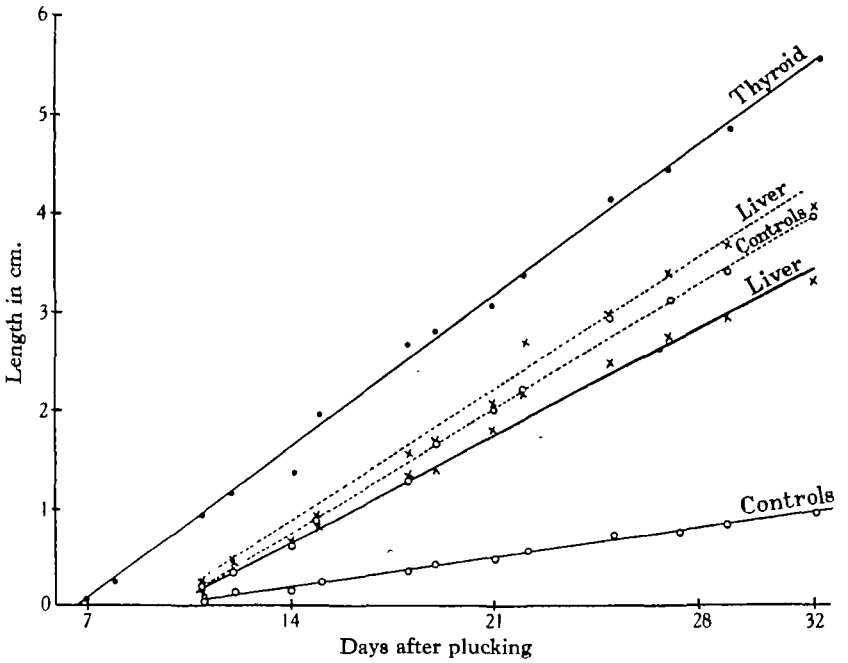

Fig. 3. Graph showing average rates of growth of thigh feathers in Rhode Island Red fowls fed excessive doses of thyroid or liver, as compared with blank controls. Similar graphs were obtained for each area plucked (neck, anterior and posterior back, anterior and posterior breast and abdomen). —— assuming each feather plucked to be capable of regeneration. - - - - considering actual number of feathers regenerated.

The experiments in group C were an attempt to confirm the results in group B, using larger numbers of birds. In this case also, the feathers regenerating after thyroid treatment grew very rapidly, whereas in the liver-fed birds and blank controls regeneration was relatively slow. Growth in all except neck and abdominal feathers after liver feeding was approximately the same as in the blank controls, but the neck feathers grew more rapidly following liver treatment, and the abdominal feathers grew more rapidly in the blank controls.

HISTOLOGY OF FOLLICLES FAILING TO REGENERATE

It has been shown in a previous paper (in press) that the rate of regeneration of feathers after plucking is dependent to a great extent on the amount of injury to the papilla. Following slight injury, the papilla heals rapidly and may give rise to a feather directly, all torn and congealed tissue becoming cornified and ultimately shed with

the sheath of the new feather. After great injury, the whole of the torn papilla may cornify following the formation of a completely new one beneath it; and in excessive injury it may be necessary for a third papilla to form before a new feather can be successfully regenerated. These stages are, however, passed through very rapidly, and even in the last case (of excessive injury) the healthy papilla is usually formed within 72 hours after plucking, the new "pin feathers", or rather the cornified mass of waste tissue due to injury, being visible at the mouth of the follicle about a week later. Thus in cases where regeneration is delayed for perhaps months after plucking, it seems unreasonable to assume that injury to the papilla is the retarding factor.

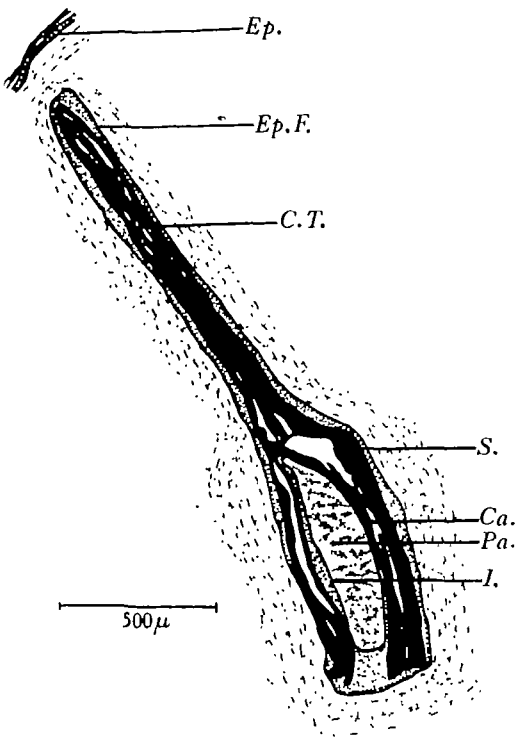

Fig. 4. Drawing of longitudinal section of feather follicle from neck of normal Rhode Island Red ♀, 8 weeks after plucking. *Ca.* calamus, *Cp.* feather cap, *C.T.* cornified tissue, *Ep.* epidermis, *Ep.F* epidermis of follicle, *I.* intermediate cells, *Pa.* papilla, *S.* sheath.

An examination of the skin from the neck, anterior and posterior back of a bird which had been plucked 8 weeks previously with no external signs of subsequent regeneration showed that two conditions may exist. The neck of deep follicles may become restricted, and contain an unidentifiable mass of cornified tissue, with a papilla at the base, presumably healthy but with slight or no traces of ridge formation (Fig. 4). Here it seems safe to assume that some impulse (*e.g.* that provided by the accelerating influence of thyroid treatment) is lacking, but this will be provided by the usual hyperthyroid condition of the bird at the next moult. Ridge formation will then be stimulated, and the papilla able to produce a new feather. The epidermis

over this papilla is in the simple state usually found in normal, quiescent papillae with the outermost layers partly cornified. This forms a structure not unlike the calamus of the old feather present between normal moults, although very thin and incompletely cornified.

The second condition often seen, usually in shallow follicles, is where the epidermis of the papilla gives rise to a very thin calamus, which usually becomes almost completely blocked by feather caps (Fig. 5). Beneath this, the papilla remains in the same state as between normal moults. This calamus cannot represent the base of the calamus of the old feather, as it is abnormally thin, and constricted at the distal end with a narrow, central opening.

When it is remembered that at each normal formation of a feather an outburst of activity takes place in the papilla, which gradually decreases so that later activity is only sufficient to form the simple structure of the calamus, it becomes clear that

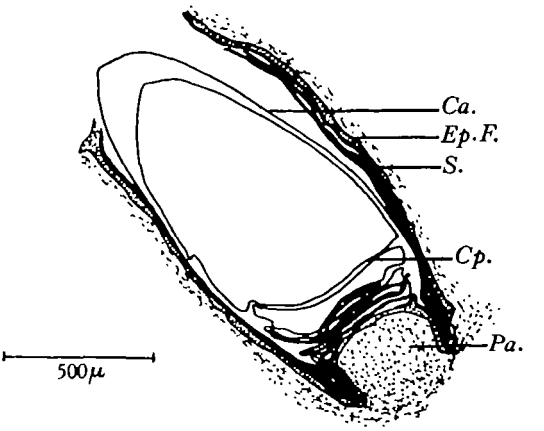

Fig. 5. Drawing of longitudinal section of feather follicle from posterior back of normal Rhode Island Red ♀, 8 weeks after plucking. Lettering as in Fig. 4.

in this type of failure to regenerate, the stimulus of plucking must cause a new burst of activity, which, however, is too slight for anything but calamus formation.

In the thyroid-fed birds, the endocrine extract forms a more potent stimulus, enabling the papilla to regenerate not merely the basal region of an inferior type of calamus, but a complete new feather.

It sometimes happens that one or two feathers out of a plucked patch regenerate very rapidly, while the remaining feathers fail to regenerate at all. This may be due to the fact that a few feathers are normally shed outside the usual moulting season, and the papillae of such feathers may therefore be expected to regenerate more rapidly than others.

SUMMARY

It may be concluded from these experiments that excessive doses of thyroid cause (*a*) moulting, followed by rapid regeneration of depigmented feathers in mature birds; (*b*) depigmentation of growing feathers followed by increased melanisation in young birds, giving a white and black bar; (*c*) accelerated growth rate in all

feathers, regardless of the region considered or the age of the bird; (*d*) stimulation of the papillae of plucked feathers causing rapid regeneration from each papilla.

From the variability in the measurements recorded, liver feeding appears to have no definite effect upon feather growth, but a slight stimulating effect upon the papillae causing them to regenerate.

In cases of lack of external signs of regeneration of feathers for some months after plucking in normal or liver-fed birds, the papilla regenerates a rudimentary calamus, or lies quiescent beneath cornified tissue which acts as a calamus, until the next moult, or until some substance with an accelerating influence upon feather growth (*e.g.* thyroid) is administered.

ACKNOWLEDGMENTS

My thanks are due to Prof. E. A. Spaul for many helpful suggestions, and for his assistance with the administration of the extracts.

This work was carried out with the assistance of funds from the Ackroyd Memorial Fellowship.

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