Chapter 10

THYROXINE INDUCED REFEATHERING OF THE INCUBATION PATCH IN HOUSE SPARROW

Good deal of work has been done by avian endorcrinologists on the mode of hormonal action in incubation patch formation in Passerine birds (Bailey, 1952; Hinde and Steel, 1964; Hohn and Cheng, 1965; Hutchinson et al., 1967; Jones, 1969a, b, 1971). The major events in the formation of incubation patch viz., defeathering, vasaularization of dermis of the exposed skin, and development of cutaneous edema, are dependent on hormonal factors, notably the sex steroids and prolactin. When incubation period in the House Sparrow (a multi-brood species known to have 6-7 clutches per breeding season - Naik and Mistry, 1970) is over, the patch regresses with loss of edema and its hypervascularity. However, refeathering of the patch skin occurs only when the general moulting takes place at the end of the breeding season. Till recently, loss of feather papillae was considered to be a normal feature of the patch formation. However, it has now been established (Chapter-5) that feather papillae persist in the patch skin, but they remain dormant and do not develop into feathers. Since the essential nature of thyroid hormone in normal feather development is well known (Voitkevich, 1966), and prolactin

(important in patch formation) is known to reduce the sensitivity of feather germs to thyroxine (Kobayashi, 1953), a strong possibility of a peripheral inhibition of thyroxine action by prolactin exists which is considered to be responsible for the suppression of feather development in the incubation patch. The present experiment was performed with a view to test indirectly, whether thyroxine insensitivity exists, and if it does, whether it could be overcome and refeathering could be induced in the patch skin by administration of high doses of thyroxine. A histochemical analysis of the patch skin was undertaken to know more about the histophysiological correlates of the morphological events.

OBSERVATIONS

Morphological

In those sparrows maintained after a single thyroxine injection, no refeathering was noted even at the end of a month in captivity.

After three injections, however, the birds were noticed to have their patch skin getting refeathered. The developing down feather stubs were noticed to be emerging from the skin surface at about the 7th or 8th day after the commencement of the experiment (Fig. 3). Besides, loss of edema of the skin was another notable feature. In most of the experimental birds, even a number of body feathers were noticed to be

1 FEMALE HOUSE SPARROW
IN NON - BREEDING SEASON
(INCUBATION PATCH ABSENT)

2 INCUBATING
FEMALE HOUSE SPARROW
(FULLY FORMED PATCH)

3 INCUBATION PATCH IN
THYROXIN TREATED
FEMALE HOUSE SPARROW
(AFTER 3 INJECTIONS

4 FEMALE HOUSE SPARROW
CONTROL (SALINE INJECTED) :
ON THE 20th DAY OF EXPERIMENT

moulting. In two specimens moulting of a secondary feather and a tail feather was also noticed.

None of the control birds (Saline injected and untreated birds) showed any evidence of refeathering of patch skin or moulting of body feathers (Fig. 4). A reduction in the degree of edema of the path skin in both the above referred cases was, however, noticed which was proportional to the length of captivity period.

Histochemical Observations

SDH : In the experimental as well as control birds, 24 hours after the 1st injection of thyroxine, SDH reactivity was noted in the epidermis of the non-patch region of the skin (feather tracts adjacent to the patch) and blood vessels in the dermis of the patch skin. The stratified epidermis of the patch skin registered higher enzyme reactivity with a low level in the feather germs.

After the 2nd injection of the hormone, there was no significant change in the overall distribution pattern of intensity of the enzyme reactivity. However, in the feather germs of the experimental birds, a slight increase in SDH activity was seen in the cells of their collar region.

With the 3rd injection of the hormone in the experimental birds, there was a reduction in SDH concentration in the patch skin epidermis, whereas the developing feathers in this

area showed a higher incidence of the enzyme. Controls at the corresponding stages showed the same level of enzyme reactivity in their skin components as was noted at the beginning of the experiment.

MDH : MDH activity in the patch skin was of moderate intensity except in the feather germs. With three successive administration of hormone doses the enzyme reactivity enhanced in feather germs only, whereas it remained unaltered in all the other parts.

LDH : The enzyme distribution pattern and its intensity in the patch skin of the non-experimental control birds was fairly high. LDH activity in the patch skin did not show any noticeable alternation in its intensity or distribution on administration of either hormone or saline.

G-6-PDH : 24 hrs after the hormonal treatment, the concentration of G-6-PDH increased in the epidermis and dermis components except the feather germs. With the second and third injections of the hormone, gradual but definite enhancement in the enzyme activity was evident in all the component parts of the patch skin, including those of feather germs; the pattern of enzyme distribution and its intensity, in the patch skin of the control bird was same all through out as was in the normal untreated birds.

BDH : Except the feather germs all components of the patch skin in the experimental and control birds exhibited

BDH activity after 1st injection of thyroxine. There was a considerable increase in reactivity of the enzyme in the feather germs after the second and third injections of the hormone.

<u>αG-GPDH</u> : Considerable αG-GPDH activity was noticed in the epidermis and dermis (except for the feather germs) of the control as well as the experimental birds. There was no discernible change in the enzyme distribution pattern after the 2nd thyroxine injection. However, after the 3rd injection of thyroxine, increase of αG-GPDH activity in the feather germs was observed; but the other components remained unaffected as far as the enzyme profile was concerned.

<u>Alkaline Phosphatase</u> : Alk Pase reactivity in the patch skin of experimental (24 hrs after 1st injection of hormone) as well as control birds (24 hrs after 1st injection of saline) was almost nil. Positive enzyme reactivity appeared in the walls of blood vessels of the dermis and feather germs, after the 2nd thyroxine injection; and it increased further in these parts a day after 3rd injection of the hormone when refeathering was externally evident.

<u>Acid Phosphatase</u> : Almost all components of the patch skin of experimental as well as control birds exhibited Ac Pase activity. However, there was no considerable change in the enzyme profile neither in the thyroxine injected nor in the saline administered birds.

DISCUSSION

Formation of incubation patch involves, ecdysis of the down feathers from the ventrum by a special moult that does not involve endysis. Growth of the next generation of feathers in the patch of House Sparrow occurs only after the breeding season. Possibility of activition of the dormant feather germs in the patch, by administration of thyroxine has been examined in the present experiment. It has become evident that the refractoriness of these feather germs cannot be overcome by low concentrations of the hormone (i.e. a single dose of thyroxine - 1 mg/0.3 ml - as in this case). It is observed that during the state of broodiness, patch skin remains bare with no evidence of refeathering. In this context, it is worth mentioning that Wodzicki (1951) found that in the case of domestic fowl, feeding with dry thyroid as well as administration of synthetic thyroid preparation failed to terminate broodiness. The feather papillae in the incubation patch skin are known to remain dormant under the influence of high levels of circulating sex steroids and/or prolactin (unpublished data). However, this state of dormancy can be over come and the dormant papillae can be induced to proliferate by the administration of adequate amount of thyroxine. Absence of refeathering of the patch skin in the two control groups of captive House Sparrows i.e., saline injected and untreated, indicate that inspite of unavailability of the appropriate nest

stimuli for maintaining the broodiness (under the experimental condition), the feather germs in the patch skin are still maintained in quiescent state during the breeding season. However, edematous condition subsides under these experimental conditions which could be due to lack of stimuli normally offered by nest and eggs. Since House Sparrow is a multibrood species, with as many as 6-7 clutches per season, refeathering of the patch skin occurs only on termination of the breeding season. However, the edematous condition is lost, in the interval between the two clutches. It is obligatory that simultaneous moulting of body feathers along with the refeathering of incubation patch on administration of thyroxine should be taken into cognizance while attempting to explain the process of refeathering, based on hormonal action. It is evident that there is no preferential or selective activation of feather papillae in the incubation patch by thyroxine that was administered, rather it evokes the general moulting. Incubation patch refeathering is known to occur during such general body moult which normally occurs only on termination of breeding activities. In female sparrows, Clench (1970) found that during the breeding season, feathers lost accidentally or pulled out, even from elsewhere on the body are not replaced, indicating that an inhibition of activation of feather germs exist in the non-patch regions of the body as well, during the breeding season. Vangien (1955) found that exogenous sex

steroids administered to House Sparrows inhibit moult. Since the wealth of information available on endocrine control of avian moulting illuminates the role of thyroid gland in the process, it is worthwhile to look into the possible mechanisms of this suppression or inhibition of moulting as possibly involving a thyroid-antagonistic mechanism. Multipronged studies on the role of thyroid in moult have projected conflicting views about its involvement in the process. Tanabe found an increase in thyroid activity as measured by radioiodine uptake before moult; but when the moulting chickens were kept warm enough, there was no change in thyroid output (Tanabe and Katsuragi, 1952). Possibly, such results prompted Farner (1978) to suggest that the role of thyroid may be mainly to compensate for increased heat loss in moulting phase. Treatment with antithyroid chemicals like thioureas inhibits moult in passerines (Wagner and Mueller, 1963), but reportedly not in the case of pigeons (Kobayashi, 1952). However, it is found that thiouracil treatment, prolonged the time span needed for restoration of plucked contour feathers in pigeon to almost double the normal period (Chapter 4). Local stimulatory effects of thyroxine on feather germs by way of mitosis (Juhn, 1963, Juhn and Harris, 1955), increased activities of certain enzymes (Kobayashi, 1954; Chapter 4) etc., are known. One of the most interesting hypothesis regarding thyroxine influence on periodic renewal of plumage, comes from Juhn

(1963), who postulated changes in the threshold of response of papillae to circulating hormone levels as an intrinsic rhythm. Influence of other hormones could modify such a threshold level of responsiveness. Sex steroids and prolactin, the levels of which are high in nesting and brooding birds respectively, are known to have inhibitory effects on moulting; particularly on the endysis phase of the moulting. Ecdysis during the special moult involved in the patch formation could be due to sex steroids, as is the case with male wattled starlings whose head remain bare (after such a moult) for several months during the breeding season, and is believed to have an epigamic function (Stressmann and Stressmann, 1966). The birds used presently for the experiment were at the peak of incubation phase, and hence could be having lowered sex steroid levels. Even the circulating levels of prolactin would be reduced in captivity due to lack of nest stimuli as evidenced by the decline in edema. However, there is a possibility that whatever fraction of these hormones that remain bound to the patch skin could influence the area concerned. Thus it is possible that feather papillae may be remaining under such influence. This assumption cannot be overlooked, till evidence to the contrary is available. If so, a peripheral inhibition of thyroxine action by prolactin as proposed by Wada et al., (1975) could be responsible for the refractoriness of feather follices. Other reports also bear out the contention of such

an antithyroidal action by prolactin in birds (Chandola and Pavgi, 1977; Kuhn and Neumen, 1978) as well as amphibia (Nicoll, 1974; Dodd and Dodd, 1976; Platt et al., 1968). These authors further postulated that thyroxine in large amounts can overcome this inhibition and the results of the present experiment amply corroborate their suggestion.

Histochemical analysis of the patch skin during such experimentally induced refeathering of patch skin also bears out the contention of thyroxine influence in the process. Enzymes such as G-6-PDH, SDH and Alk Pase, which are known to be influenced by thyroxine and recognized as essential for normal feather development (Chapter 4), showed a low profile in the patch skin of untreated as well as saline injected controls; whereas in the thyroxine treated birds, an increase in their activities was discernible in the feather forming tissues concomitant with refeathering of the incubation patch skin. Inhibition of thyroxine mediated events through declined activities of enzymes are known to occur in case of amphibian tadpole tail tissue during metamorphisis (Jaffe and Geschwind, 1974; Yoshizato and Yasumasu, 1972a,b). Thus it appears that a local stimulatory influence of thyroxine on metabolic events in the feather forming tissue, is responsible for the induced refeathering of the patch skin.