

Hair Color, Molt, and Testis Size in Male, Short-Tailed Weasels Treated with Melatonin

Abstract. *Melatonin in beeswax was implanted in male weasels (Mustela erminea). Brown weasels and white animals undergoing the spring change to the brown pelage and reproductive activity molted, grew a new white coat, and became reproductively quiescent after treatment. Controls retained or acquired the brown coat and developed or maintained enlarged testes. Treated weasels with pituitary autografts under the kidney capsule grew brown hair after hair growth was initiated by plucking. It is suggested that the pineal gland product, melatonin, initiates changes in the central nervous system and endocrines which result in molting, growth of the white winter pelage, and reproductive quiescence in the weasel.*

Weasels exhibit seasonal changes in pelage. An increase in day length initiates molting and growth of brown hair (summer phase) while a decrease in day length causes the white pelage (winter phase) to develop (1). Seasonal pelage changes are dependent upon the pituitary gland since hypophysectomy is followed by the growth and maintenance of the white coat regardless of photoperiod. Growth of brown hair can be induced in hypophysectomized weasels by treating them with exogenous purified melanocyte-stimulating hormone (MSH) or adrenocorticotropin after hair growth is initiated by plucking (2). Weasels with pituitary autografts under the kidney capsule grow only brown hair, even when exposed to environmental stimuli that induce the growth of the white coat in intact animals (3). It is probable, therefore, that the central nervous system exhibits a seasonal inhibitory influence over the production or secretion (or both) of MSH.

The hypothalamus inhibits MSH secretion in the frog (4). The presence of a MSH-release-inhibiting factor has been demonstrated in the rat (5) and other animals (6), and appears to be the major regulator of MSH secretion. Kastin and Schally (7) have shown that melatonin, which is produced by the pineal gland (8), decreases pituitary MSH in the rat and have suggested that light may influence the amount by a mechanism involving melatonin and the MSH-release-inhibiting factor (9).

We have tested the hypothesis that the pineal gland is involved in the control of hair color in the weasel by regulating the release of MSH from the pituitary gland. Male, short-tailed weasels (*Mustela erminea*) (100 to 200 g) were obtained from trappers in Alberta, Canada, and Price County, Wisconsin. After the animals arrived in Madison, Wisconsin, they were maintained in a

room having a temperature of about 22°C and an artificial photoperiod in which the ratio of light (L) to dark (D) was 14:10. The care and feeding of the weasels has been described (2, 3). Each weasel was vaccinated with 1 ml of mink distemper vaccine (10) and treated for external parasites with tick and flea spray (11).

Melatonin (12) in beeswax was implanted subcutaneously in three groups of weasels by inserting the implants through a small dorsal skin incision while the animals were anesthetized with ether. The implants were prepared by mixing 1.0 mg of melatonin with 25 mg of beeswax and then flattening the mixture to form a disk about 12 mm in diameter.

Hair growth was induced by plucking hair from the dorsal surface each time an implant was inserted. Testis size was determined by palpating the scrotal region, as described by Wright (13). Stage 1 represented the fully regressed condition, stages 2 and 3, the intermediate sizes, and stage 4, the maximum size.

Nine brown weasels with enlarged

testes were treated with three melatonin implants inserted consecutively at weekly intervals (group 1). Seven of these animals grew white hair in all plucked areas, molted, grew a new white coat, and, as judged by the regression of the testes, became reproductively quiescent (Table 1). Brown hair appeared in the plucked areas of two treated weasels 15 days after the first implant was made. These animals were treated with a fourth melatonin implant and subsequently molted and grew a white coat. Control animals that received beeswax maintained enlarged testes, kept the brown pelage, and grew brown hair after hair growth was initiated by plucking.

The molt in the treated weasels in group 1 began on the ventral surface after the second or third implant was inserted and proceeded dorsally, as is typical of the fall molt in this species (14). The growth of the new coat was completed 30 to 40 days later.

The implants were removed after the weasels had grown the new white coat. Hair growth was initiated every 2 weeks by plucking until the animals grew brown hair—from 40 to 116 days after removal of the implants. Molting, growth of a new brown coat, and testicular enlargement followed the growth of brown hair in the plucked areas.

Eleven weasels (group 2) in the white winter pelage were moved into the laboratory on 16 November. The change from the natural environment in November to the photoperiod of LD 14:10 in the laboratory probably stimulated pituitary activity because molting, growth of brown hair, and testicular enlargement were observed in most animals in mid-December when melatonin

Table 1. Effect of melatonin on hair color, molt, and testis size in male, short-tailed weasels. Group 1 was treated with 1.0 mg of melatonin (in 25 mg of beeswax) per week for 3 weeks. The controls were given the beeswax alone. Group 2 was given the same treatment as group 1, except the treatment was given for 4 weeks. Group 3 was given a renal capsular pituitary autograft and 1.0 mg of melatonin per week for 5 weeks in 25 mg of beeswax. There were no controls for group 3.

Treatment	Animals (No.)	Hair color		Molted (No.)	Testis size (stage)*	
		Before treatment	After treatment		Before treatment	After treatment

Group 1						
Test group	9	Brown	White	9	2-3	1
Control	6	Brown	Brown	0	2-3	2-3
Group 2						
Test group	6	White	White	6	1	1
Control	5	White	Brown	5	1	3-4
Group 3						
Test group	3	Brown	Brown	3†	2-3	1
Test group	4	White	Brown	4†	1	1

* Determined by palpation.

† Molt took place after renal capsular pituitary autografts were made.

treatment was initiated. Six animals were treated with four melatonin implants inserted consecutively at weekly intervals while five were given beeswax implants. Molting from the dorsal surface, growth of brown hair, and testicular enlargement ceased 20 to 30 days after treatment was begun. Molting from the ventral surface, growth of new white hair, and testicular regression was evident 10 to 20 days later. Molting ceased and the testes became completely regressed 60 to 70 days after treatment. The hair on the dorsal surface was not shed in most animals, so that the weasels were white with brown patches on the back. Controls molted, grew a new brown pelage, and developed enlarged testes.

Pituitary autografts were made under the kidney capsule in three brown and four white weasels (group 3) in November. Hair growth was initiated by plucking on the day the autografts were made. Melatonin treatment was started 14 to 20 days after surgery when new brown hair appeared in the plucked area. Five implants were inserted at consecutive weekly intervals, and hair was plucked after each implant was made.

Animals molted after the pituitary autografts were made. Some additional shedding was noted in these animals after the melatonin treatment was initiated, but in all cases the hair that grew after molting or plucking was brown (Table 1).

Melatonin appeared to have an inhibitory effect on the initiation of hair growth in some weasels in groups 2 and 3. The time between the implants and the appearance of hair ranged from 24 to 51 days in some treated animals, whereas the tips of new hairs could be seen in all control and most treated weasels 14 to 20 days after plucking.

Melatonin inhibited the effect of the long-day photoperiod and induced the fall molt, growth of the white pelage, and testicular regression in weasels in group 1. Melatonin also stopped and reversed the effects of increased day length in the weasels in group 2, as indicated by molting, growth of white rather than brown hair, and a decrease in the size of the testes.

The inhibition of hair pigmentation observed in intact weasels treated with melatonin indicates that the pineal gland is involved in the seasonal control of hair color. The central nervous system exhibits an inhibitory influence over the production and secretion of

MSH in the weasel (3). Since weasels with pituitary autografts grew brown hair when treated with melatonin, it is probable that melatonin does not act directly on the pituitary gland to inhibit MSH secretion.

The MSH-release-inhibiting factor has been demonstrated in the rat and other animals (5, 6); it decreases the content of MSH in the plasma and elevates that in the pituitary (15). On the basis of our data and those cited, we postulate that melatonin acts on the hypothalamus causing the release of this inhibitor in the weasel.

The inhibitory effects of melatonin on reproduction in the rat have been documented (16, 17). The regression of the testes observed in intact weasels treated with melatonin suggests that the pineal gland may also be involved in the regulation of seasonal reproductive changes in addition to pelage cycles.

CHARLES C. RUST*

Regional Primate Research Center,
University of Wisconsin, Madison

ROLAND K. MEYER

Department of Zoology,
University of Wisconsin

References and Notes

1. T. H. Bissonnette and E. E. Bailey, *Ann. N.Y. Acad. Sci.* **45**, 221 (1944).
2. C. C. Rust, *Gen. Comp. Endocrinol.* **5**, 222 (1965).
3. — and R. K. Meyer, *ibid.* **11**, 548 (1968).
4. W. Etkin, *ibid.* **1** (Suppl.), 148 (1962); A. J. Kastin and G. T. Ross, *Endocrinology* **77**, 45 (1965).
5. A. J. Kastin and A. V. Schally, *Gen. Comp. Endocrinol.* **7**, 452 (1966).
6. —, *Nature* **213**, 1238 (1967); A. V. Schally and A. J. Kastin, *Endocrinology* **79**, 768 (1966).
7. A. J. Kastin and A. V. Schally, *Gen. Comp. Endocrinol.* **8**, 344 (1967).
8. R. J. Wurtman, J. Axelrod, E. W. Chu, *Science* **141**, 277 (1963).
9. A. J. Kastin, A. V. Schally, S. Viosca, L. Barrett, T. W. Redding, *Neuroendocrinology* **2**, 257 (1967).
10. Biological Specialties Corporation, Middleton, Wisconsin 53562.
11. Polk Miller Products Corporation, Richmond, Virginia 23230.
12. Mann Research Laboratories, New York 10006.
13. P. L. Wright, *J. Exp. Zool.* **91**, 103 (1942).
14. H. H. T. Jackson, *Mammals of Wisconsin* (Univ. of Wisconsin Press, Madison, 1961), pp. 338–342.
15. A. J. Kastin, M. C. Miller, A. V. Schally, *Endocrinology* **83**, 137 (1968).
16. R. J. Wurtman, J. Axelrod, L. Phillips, *Science* **142**, 1071 (1963).
17. E. W. Chu, R. J. Wurtman, J. Axelrod, *Endocrinology* **75**, 238 (1964).
18. Supported in part by Ford Foundation grant 63-505.
- * On leave from the Department of Botany and Zoology, University of Wisconsin Center, Janesville 53545.

24 April 1969; revised 26 June 1969

Orientation by Pigeons: Is the Sun Necessary?

Abstract. *Although most recent hypotheses of pigeon homing have assigned an essential role to the sun, there has been some evidence suggesting that the sun is not essential. Two series of releases were designed to examine the question more carefully. Birds whose internal clocks had been shifted 6 hours were used in the critical tests. Under sun, the vanishing bearings of the clock-shifted birds were deflected in the direction predicted by a hypothesis of use of the sun as a simple compass. By contrast, under total overcast the bearings of both the clock-shifted and the control birds were homeward oriented and there was no difference between them, even at a release site the birds could never have seen previously. Therefore it is concluded that the sun is used as a compass when it is available, but that the pigeon navigation system contains sufficient redundancy to make accurate orientation possible in the absence of both the sun and familiar landmarks; the orientational cues used under such conditions do not require time compensation. This conclusion is in complete disagreement with the Matthews sun-arc hypothesis of pigeon navigation, and it makes necessary a major reformulation (at the very least) of the other principal hypothesis, that of Kramer.*

For roughly the last 20 years, there has been much emphasis on the sun in research on pigeon homing. In a series of papers, Kramer and his colleagues (1) showed that both wild migrant birds and pigeons can use the sun as a compass to choose a direction in a circular cage. Matthews (2, 3) went further, erecting a hypothesis of complete navigation by the sun. He suggested that a pigeon displaced from home could determine its latitudinal displacement by extrapolating the sun's arc at the release point to its highest (noon) position and

comparing its altitude with the remembered noon altitude of the sun at home. According to Matthews, the bird could determine its longitudinal displacement by, in effect, comparing sun time at the release point with home time, as indicated by the bird's internal sense of time, or "internal clock." With information about both its latitudinal and its longitudinal displacement, the bird could then determine the direction it must fly to get home. Although the results of many investigators have appeared to support the idea that pigeons