THE EFFECT OF SYMPATHECTOMY ON WOOL GROWTH

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Summary

Five sheep (two Merinos, two Corriedales, and one crossbred) were subjected to unilateral thoracic sympathectomy. Fleece samples were collected at 28-day intervals, for a period of seven months, from tattooed areas of skin on both the sympathectomized and control sides.

The results show a mean increase of 36 per cent. in wool growth rate on the sympathectomized side over the control side for ten weeks after the operation. This effect then disappeared so that no difference between the two sides was observed over the remainder of the experimental period. It is suggested that the initial effect of sympathectomy on wool growth rate was brought about by vasodilation of the denervated vessels and that the subsequent disappearance of this effect was due to the onset of warmer weather causing vasodilation of the control side.

Skin surface temperature showed a significant increase on the sympathectomized side immediately after the operation but this effect also disappeared within a few weeks so that no difference was detected during the fleece collection periods. Skin surface temperature may have been depressed on the sympathectomized side during the process of actual measurement due to constriction of the denervated cutaneous vessels caused by nervous excitement.

I. Introduction

Recent observations on the relation of wool growth rate to atmospheric temperature (Ferguson, Carter, and Hardy 1948) might be explained by the well-known effect of environmental temperature on the peripheral blood circulation with concomitant variation of the nutrient supply to the wool follicles. As such an effect, if present, is probably mediated via the sympathetic vasoconstrictor nerves to the cutaneous vessels, it follows that sympathectomy would increase wool growth and thus tend to confirm our explanation. This hypothesis is supported by the observation that section of the sympathetic nerves to one ear in rabbits and cats causes a speedier regrowth of hair on the denervated side (Pye-Smith 1887; Grant 1935) and has now been subjected to further experimental test in the sheep.

II. Material and Methods

The experimental sheep were all ewes and comprised two Corriedales, two Merinos, and one crossbred. Two sheep were sympathectomized on the right side and three on the left. Under barbiturate anaesthesia, an incision about

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10 inches long was made parallel to the 9th rib. The periosteum was stripped from the 9th and 10th ribs and about 6 inches of bone from the dorsal end of each removed. Without penetrating the pleura, the sympathetic trunk was reached in the dorsal part of the chest cavity. Five ganglia (8th-12th thoracic) and the intervening trunk were removed.

Fleece growth was measured by clipping areas of 100 sq. cm. delineated by a tattooed square on each midside region. Measurement was commenced from 2 to 6 weeks after the operations on 4 of the sheep: clippings were taken at fortnightly intervals for 4 weeks and subsequently at 4-weekly intervals. The 5th sheep (F 338) was added to the experiment 4 weeks after the others and 16 days after she had been sympathectomized. Fleece samples for the determination of fibre length and fibre diameter were taken from the anterior margin of each tattooed area.

Prior to the first fleece-collection period, the sheep were closely clipped over the whole surface of the body and three of them were clipped again later in the experiment to note whether the removal of the fleece insulation affected the sympathectomized and control sides differently, as it might be expected to do.

One of the sheep (UNI. 2) lambed shortly after being sympathectomized. The lamb was removed 4 weeks after the commencement of the first collection period. This sheep died from an abscess on the shoulder 8 weeks later.

No attempt was made to control the plane of nutrition strictly from period to period in that the diet was prepared as required and not mixed beforehand for the whole experiment. Variations in dietary intake were, however, unimportant, as the experimental comparisons were between the sides of each sheep and not between sheep. Two sheep (254 and 249) were given 450 g. of feed per day, later increased to 900 g. per day. The other three (UNI. 2, F 338, and N.T.) were given 600 g. per day throughout except for UNI. 2 which was fed *ad libitum* on lucerne chaff while nursing her lamb.

Measurements of the temperature of the skin surface at 9 points on each tattooed area were made after each fleece clipping by means of a nichrome-constantan thermocouple connected to a potentiometer.

III. Results

Examination of the data showed an increase in wool growth on the sympathectomized over the control side except in one sheep (UNI. 2). However, after 12 weeks of measurement there was a rather sudden disappearance of the difference between the two sides in all except one sheep (249). The data are, therefore, conveniently summarized by taking the mean values for each sheep over the first 12 weeks of measurement and over the remainder of the experiment (Table 1). The values of wool, wax, and suint weight are given per tattooed area per 28 days.

In the Table, the mean increase of values on the sympathectomized side as a percentage of the control side is shown, and the probabilities that the

mean differences between the sides would be exceeded for reasons other than the operative treatment are also indicated. "Student's" '*t*' distribution was used to calculate the probability values. In the first period the probabilities for wool weight, fibre length, and possibly fibre diameter, are suggestive of a real treatment effect. Disappearance of the effect in the second period strengthens the conclusion of a true effect in the first, as the largest source of error variation is likely to have come from pre-treatment differences between the sides which would not tend to disappear.

As the samples for measurement of fibre length and diameter were not from exactly the same area as those for that of wool weight, it cannot be expected that the observed changes in length and diameter will account exactly for the changes in wool weight, assuming that sympathectomy does not affect the number of fibres growing. However, with this assumption, the observed increases in fibre length and diameter give a theoretical increase in wool weight of 32 per cent. for the first period which corresponds reasonably well with the observed value of 36 per cent.

The Table does not indicate a significant effect of the operation on the skin temperature of the tattooed area. In fact, the temperature on the control sides has a tendency to be higher. However, in the first measurement of skin temperature at the beginning of the first fleece-collection period, the mean temperature was slightly higher (0.8°C.) on the sympathectomized side, and earlier measurements on one sheep (UNI. 2) showed a temperature increase of several degrees on the side operated upon which diminished as the time after the operation increased. In only one sheep (249) did the temperature remain greater on the sympathectomized side throughout the experiment. This was also the only sheep in which a difference in wool growth rate persisted.

Although individual differences in wax weight between "operated" and control sides are rather large they are not consistent in direction and cannot be ascribed to the treatment. It must be concluded either that the treatment has affected wax production differently in the several individuals or that the differences existed prior to the treatment. The differences cannot be due to random variation in technique of wax extraction as the 4-weekly analyses consistently maintain the mean differences shown in the Table. One might infer from the data that sympathectomy reduces suint secretion but the probability values are too high to allow this conclusion to be drawn.

No consistent effect of clipping the sheep closely all over on the difference in fleece growth between the sides was observed.

IV. Discussion

The rapid disappearance of the skin temperature difference between the sides is in accord with the observed recovery of vascular tone following denervation first reported by Goltz and Freusberg (1874) and later repeatedly

TABLE 1

RESULTS OF SYMPATHECTOMY ON FLEECE GROWTH, GLAND SECRETIONS, AND SKIN SURFACE TEMPERATURE

Sheep No.	Date of Operation	Side	June 29 to September 8, 1948						September 9, 1948 to January 26, 1949					
			Wool Weight (g.)	Fibre Length (mm.)	Fibre Diameter	Wax Weight (g.)	Suint Weight (g.)	Skin Temperature (°C.)	Wool Weight (g.)	Fibre Length (mm.)	Fibre Diameter	Wax Weight (g.)	Suint Weight (g.)	Skin Temperature (°C.)
249		S* (left)	1.193	11.62	26.8	0.387	0.089	32.00	2.226	11.52	27.4	0.365	0.175	33.50
(Corriedale)	27.v.1948	C** (right)	0.799	9.26	24.0	0.237	0.090	31.69	1.943	10.83	25.1	0.299	0.187	32.98
		Difference	0.394	2.36	2.8	0.150	− 0.001	0.31	0.283	0.69	2.3	0.066	− 0.012	0.52
254		S (right)	0.622	10.55	25.4	0.433	0.086	31.30	1.522	11.53	27.3	0.370	0.108	33.11
(Corriedale)	2.vi.1948	C (left)	0.348	8.52	21.7	0.218	0.053	31.22	1.682	11.13	26.2	0.342	0.144	34.00
		Difference	0.274	2.03	3.7	0.215	0.033	0.08	− 0.160	0.40	1.1	0.028	− 0.036	− 0.89
UNI. 2		S (right)	0.943	9.10	24.1	0.360	0.073	32.76						
(crossbred)	6.v.1948	C (left)	0.941	9.41	22.4	0.510	0.091	33.31				Dead		
		Difference	0.002	− 0.31	1.7	− 0.150	− 0.018	− 0.55						
N.T.		S (left)	1.474	8.60	24.2	1.230	0.195	32.40	1.179	8.04	21.5	0.595	0.207	35.05
(Merino)	17.v.1948	C (right)	1.309	7.93	26.0	1.475	0.293	32.54	1.114	7.84	22.5	0.659	0.199	35.19
		Difference	0.165	0.67	− 1.8	− 0.245	− 0.098	− 0.14	0.065	0.20	− 1.0	− 0.064	0.008	− 0.14
F 338		S (left)	1.766	9.54	22.6	0.771	0.092	31.20	1.092	9.36	21.5	0.584	0.305	34.70
(Merino)	28.vi.1948	C (right)	1.002	7.86	20.4	1.052	0.249	31.77	1.220	9.29	21.2	0.667	0.411	34.81
		Difference	0.764	1.68	2.2	− 0.281	− 0.157	− 0.57	− 0.128	0.07	0.3	− 0.083	− 0.106	− 0.11
Mean		S	1.200	9.88	24.6	0.636	0.107	31.93	1.505	10.11	24.4	0.478	0.199	34.09
		C	0.880	8.60	22.9	0.698	0.155	32.11	1.490	9.77	23.8	0.494	0.235	34.24
		Difference	0.320	1.29	1.7	− 0.062	− 0.048	− 0.17	0.015	0.34	0.7	− 0.016	− 0.036	− 0.15
% Increase on Sympathectomized Side			36	15	7	− 9	− 31	− 0.6	1	3	3	− 3	− 15	− 0.3
		Probability	0.07	0.06	0.14	0.57	0.24	0.37	0.89	0.09	0.94	0.68	0.24	0.64

* Sympathectomized. ** Control.

confirmed. Grant (loc. cit.) in a detailed investigation of the effect of denervation of the rabbit's ear found that vascular tone returns in 5-7 days. Other investigators have found similar periods of recovery.

The return of vascular tone is accompanied by a greater sensitivity of the vessels to vasoconstrictor and vasodilator substances and to local mechanical and thermal stimuli (Elliott 1905; Dale and Richards 1918); Freeman, Smithwick, and White 1934; Grant loc. cit.). It seems possible that the recovery of vascular tone is due to the response of the more reactive denervated vessels to a circulating vasoconstrictor substance. Grant's work suggests that the substance is liberated during nervous excitement or muscular activity and that when the animal is completely relaxed the denervated vessels become dilated no matter whether the normal vessels are constricted or dilated. Of importance to the present discussion is the fact that increased heat loss by general cooling of the body does not cause constriction of the denervated as it does of the normal vessels as long as the animal remains relaxed. The nature of the hypothetical vasoconstrictor substance and the explanation of the greater reactivity of denervated vessels are at present unknown.

The discrepancy in the differences in wool growth rate and skin temperature between sides of the sheep may therefore be due to insufficient relaxation of the sheep at the actual time of measurement of skin temperature so that the values for the denervated side were below the mean value for the wool growth period. A continuous record of skin temperature may have shown differences in skin temperature more comparable with the wool growth values.

The disappearance of the difference in wool growth rate between sympathectomized and control sides occurred at about the same time in the sheep operated on at different periods and coincided with the onset of warmer weather. It is suggested that the warmer conditions reducing heat loss to a critical point caused a reduction of vasoconstrictor impulses to the normally innervated vessels thereby increasing blood flow and wool growth rate to the same level as the sympathectomized side. Such an explanation would be substantiated by a recurrence of the difference between the sides with the return of colder weather.

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VI. References

DALE, H. H., and RICHARDS, A. N. (1918).—*J. Physiol.* **52**: 110.
ELLIOT, T. R. (1905).—Ibid. **32**: 401.
FERGUSON, K. A., CARTER, H. B., and HARDY, M. H. (1949).—*Aust. J. Sci. Res.* B **2** (1): 42.
FREEMAN, N. E. SMITHWICK, R. H., and WHITE, J. C. (1934).—*Amer. J. Physiol.* **107**: 529.
GOLTZ, F., and FREUSBERG, A. (1874).—*Pflüg. Arch. ges. Physiol.* **9**: 174.
GRANT, R. T. (1935).—*Clin. Sci.* **2**: 1.
PYE-SMITH, P. H. (1887).—*J. Physiol.* **8**: 25.