THE INFLUENCE OF ELEVATED ENVIRONMENTAL TEMPERATURE AND HUMIDITY ON THE WHITE LEGHORN X AUSTRALORP LAYER

D. BALNAVE*

The reduced growth and reproductive performance of birds kept under hot summer conditions has led to a continuous appraisal of the role of environmental temperature on avian metabolism. Since the effects of temperature primarily influence energy metabolism particular emphasis has been given to those factors which influence metabolisable energy (M.E.) intake and energy expenditure (Balnave, 1974; van Kampen, 1974). However, since the studies of Payne (1968) it is now recognised that the intake of other essential nutrients, such as amino acids and minerals, are also important in optimising production.

In a paper delivered to this Conference Pell (1978) reviewed present knowledge and the results of recent nutritional studies with laying hens at high environmental temperatures. This review is significant in that a survey of the references cited highlights the lack of research into this problem in Australia. This is strange considering the extremes and varieties of climate encountered in Australia.

While it is possible, by studying overseas research, to derive general conclusions concerning the responses of laying hens to different climatic environments, it is not possible by this means to obtain specific data relating to particular conditions and stock under Australian conditions. Wilson and Plaister (1951), Kheireldin and Schaffner (1954) and Berman and Snapir (1965) have confirmed the importance of genetic x environmental temperature interactions.

In general, much of the overseas work has been conducted at temperatures which would not cause serious concern in Australia (i.e. less than 33°C). In addition, the majority of the recent work has been conducted with White Leghorn stock which, in all probability, react differently at specific temperatures to the crossbred bird used in Australia. This latter bird has been exposed over a great number of years, with minimum protection, to the extreme Australian summer environment. Therefore, the generally accepted concept that White Leghorn stock are more resistant to hightemperatures than heavier body weight birds (Hutt, 1938) requires verification with regard to the Australian White Leghorn x Australorp crossbred.

---

*Poultry Husbandry Research Foundation, Department of Animal Husbandry, University of Sydney, Camden, N.S.W. 2570.

The other aspect of temperature which bears scrutinyis the high diurnal temperature variation which occurs in Australia. In summer this can be as large as 20°C and variable in range and direction, and here again overseas studies have usually concentrated either on constant elevated temperatures or small constant diurnal temperature fluctuations of around ± 5°C. The extent of this diurnal temperature variation should be considered since Squibb (1959) suggested that birds were able to cope better at high temperatures and humidities when the diurnal temperature variation was large.

Evaporative heat loss assumes increasing importance above 24°C (see Balnave, 1974) but the effectiveness of evaporation decreases with increasing relative humidity. Therefore, the bird's response to elevated temperatures is related to the relative humidity of the air and also to the degree of acclimatisation of the bird. Both these factors should be considered in any attempt to estimate the responses of birds to different climates.

Recent studies conducted at Camden have shown that the nutrient requirements of Australian stock need not necessarily conform with those reported overseas. In these studies the total sulphur amino acid requirements of growing broilers have been shown to be met by a dietary concentration of 7.5 g/kg (Derilo, Unpublished Results; MacAlpine, Unpublished Results) which is considerably lower than overseas estimates (A.R.C., 1975). It is therefore possible that under extreme environmental conditions the nutrient requirements and production characteristics of Australian layers may also differ from overseas stock.

Accordingly, recent studies have been initiated at Camden to study the responses of White Leghorn x Australorp crossbred laying hens to elevated environmental temperatures and humidities. The latter conditions, and times of exposure, were chosen to simulate typical summer conditions at Camden so that the maximum heat stress conditions occurred between approximately 1100 and 1800 hrs. Lights were provided between 0500 and 2100 hours. The birds were kept in individual cages and fed daily a commercial diet containing approximately 165 g crude protein and 11.5 MJ of ME per kg. Feed intake was recorded at 1100, 1630 and 2030 hours and egg weight determined on one day of each week. The birds used in the first experiment were second year layers; those in the second experiment had just passed peak-lay in their, first laying year.

The present paper summarises the initial results of these Camden studies. The results in this paper relating to production parameters and dietary metabolisability were carried out with Ms. M. Daniel (Daniel and Balnave, Unpublished Results); those relating to biotin with Mr. W.L. Bryden (Bryden and Balnave, Unpublished Results).

Food Intake

Estimates of the reduction in food intake with increasing temperature, based on overseas studies, have shown a compound percentage reduction of approximately 1.6% per °C from -5°C to 30°C (Payne, 1968; A.R.C., 1975) with much larger reductions at higher temperatures (Smith, 1972a, 1973; A.R.C., 1975).

TABLE 1. Percentage compound reduction in feed intake with increasing temperature of crossbred laying hens exposed to simulated N.S.W. summer conditions

Experiment No.	Control Temperature °C	Experimental Conditions		Compound % reduction per °C (relative to control birds)
		Day	Night	
1	18°C	36°C, Low RH	18°C, High RH	0.32
	18°C	36°C, High RH	28°C, High RH	1.18
2	20°C	36°C, Low RH	20°C, High RH	1.44
	20°C	36°C, High RH	28°C, High RH	1.99
	20°C	36°C, High RH	28°C, High RH	1.72
		(4 hr extended evening photoperiod)		
3	20°C	30°C, Low RH	20°C, High RH	1.09

RH = Relative Humidity
Day Low RH = 40% High RH = 65%
Night Low RH = 40% High RH = 90%

The results of the Camden studies are shown in Table 1. These indicate that, when based on the maximum daytime temperatures applied, the reduction in food intake in Australian crossbred layers is much lower than would be predicted from the overseas suggestions. Even under. maximal heat stress, with high day and night temperatures and high constant humidities, the maximum percentage compound reduction was 2% per °C. During the period of acclimatisation the reduction in food intake was much lower.

In Experiments 1 and 2 the total daily weight of food eaten during maximum heat stress conditions was depressed by 19 and 27 per cent respectively compared with controls (Table 2). In both experiments the food intake during the afternoon period of maximum heat stress was reduced by 50 per cent. In Experiment 1 food. intake during the cooler morning period was increased relative to controls but in Experiment 2 food intake was reduced at all times of the day although the reduction was least during the cooler evening period.

Increasing the photoperiod 'from 16 to 20 hours did not result in an increase in feed intake when this was applied during the cooler evening period. Douglas (1979) has also found that increasing the photoperiod from 14 to 18 hours per day by increasing the light early in the morning failed to increase feed intake. Perhaps these results imply that the 'memory' of a recurring heat stress is sufficient to cause self-regulation of food intake irrespective of the time-food is available at more amenable temperatures.

The M.E. intakes of the birds at 18 and 36°C were higher than the minimum M.E. requirements calculated for these temperatures by Balnave _et al_. (1978). The M.E. intakes are also higher'than typical intakes

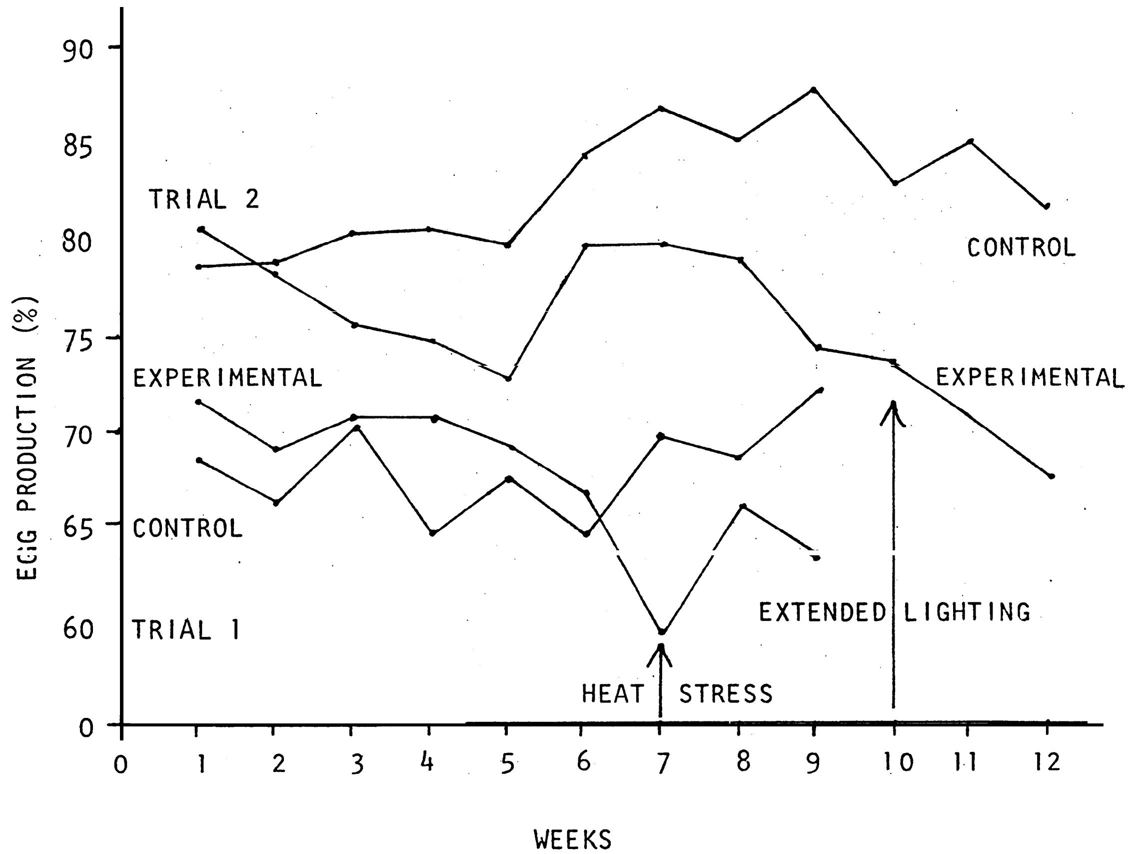

Figure 1. Egg production response to heat stress.

TABLE 2. Food intake during heat stress (relative to controls = 100)

	Experiment 1			Experiment 2		
	M	A	E	M	A	E
Acclimatisation	118 (40.5)*	69 (51.6)	102 (42.5)	90 (36.4)	55 (39.1)	94 (40.5)
Maximum Heat Stress	106 (43.0)	53 (50.3)	89 (44.5)	76 (37.9)	51 (40.9)	91 (42.8)

* Food intake of control birds (g/bird)

M = 2100-1100 hrs
A = 1100-1630 hrs
E = 1630-2100 hrs

observed in crossbred birds in southern Queensland (Connor, Personal Communication).'

Egg Production

A reduction in the rate-of lay is a characteristic response of birds to elevated temperatures. The temperature to which normal egg production may be maintained is dependant on the intakes of essential nutrients (Payne, 1966, 1968). In particular, emphasis should be given to meeting the nutrient requirements for amino acids and calcium (Emmans, 1974).

The results of two studies conducted at Camden are shown in Figure 1. These data indicate that the birds responded differently in the two experiments although they were of similar genetic stock but different age. In Experiment 1, a reduction of only 7% in the rate of lay was observed during the maximum heat stress period compared with control birds maintained at 18°C, but a much greater reduction was observed in Experiment 2. This latter effect was accentuated by 'increasing 'the photoperiod and the feeding time during the cooler evening period. Douglas (1979) found no improvement in egg production when the time of access to food was increased during the cooler morning hours, and this, presumably, reflected the inability of the birds to increase feed intake by this procedure.

Egg Weight

The effects of temperature on egg weight are shown in Figure 2. The initial marked reduction in egg weight in Experiment 1 occurred prior to any major reduction in food intake. This indicates that temperature per se had a detrimental effect on egg weight and suggests that under high summer temperature conditions losses in egg weight are unlikely to be overcome by nutritional means. However, in Experiment 2 no major reduction in egg weight relative to control birds occurred during the period of acclimatisation, although food intake was substantially reduced during this time. In Experiment 2 increasing the photoperiod during the cooler evening period did not result in any improvement in egg weight.

Daily Egg Mass

Daily egg mass was'substantially reduced in birds exposed to the heat stress conditions. The reductions relative to control birds were similar in both experiments (16%), but in Experiment 1 this was due primarily to a decline in egg weight while in Experiment 2 the major effect was exerted through the rate of lay.

Dietary Metabolizability

The M.E. value of the diet fed in these studies was not significantly influenced by the environmental conditions in which the birds were kept. Smith (1972b) found no significant difference in the M.E. of diets fed to birds maintained at either 21 or 32°C but a significant reduction was observed with birds maintained at 38°C.

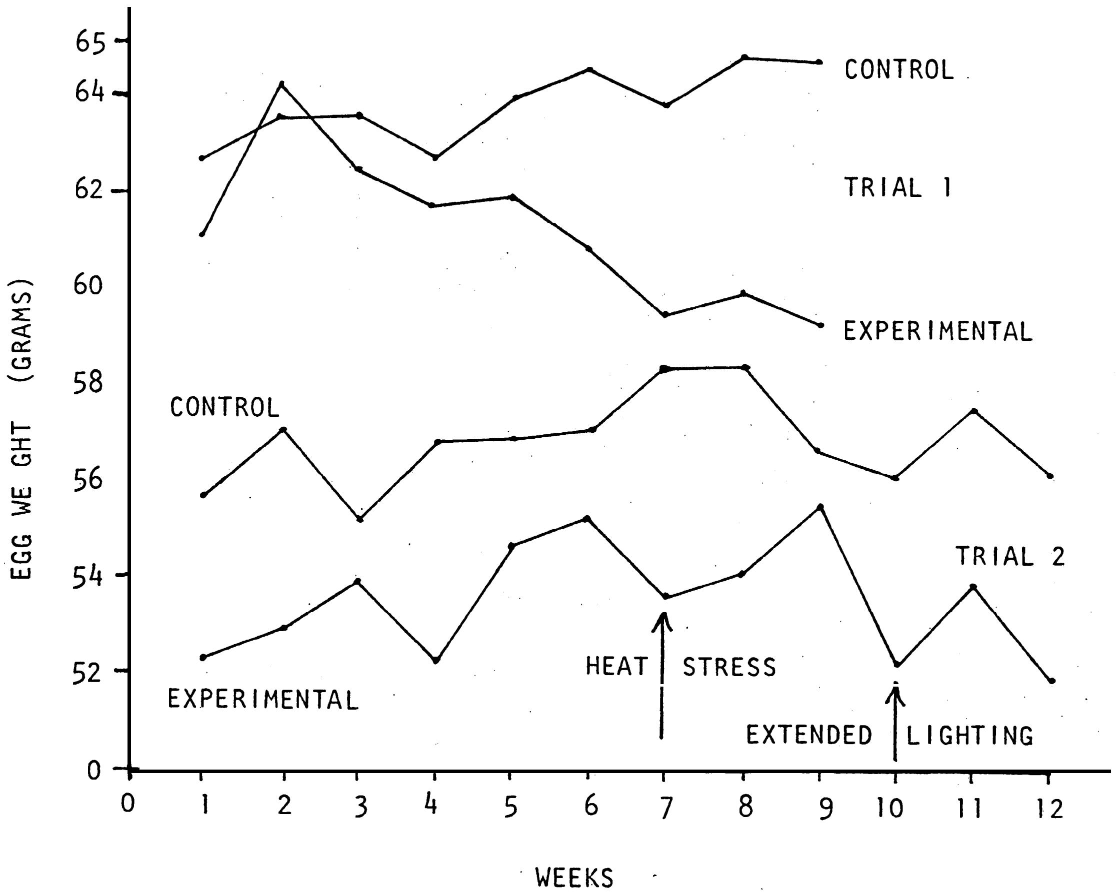

Figure 2. Egg weight response to heat stress.

TABLE 3. Blood plasma and egg yolk levels of biotin following exposure to 40°C and high relative humidity

	Plasma biotin at maximum heat stress (µg/l)	Egg yolk biotin (µg/g)		
		Pre-stress	Heat stress	Post-stress
Control (18°C)	29.5 ± 3.0(8)*	1.31 ± 0.19(6)	1.69 ± 0.15(6)	1.68 ± 0.14(8)
Experimental	55.2 ± 8.6(6)	1.04 ± 0.17(5)	2.03 ± 0.44(3)	2.30 ± 0.36(4)

*Number of determinations

Egg Yolk Formation

Although mean egg weight was reduced in birds maintained at **high** temperatures the relative proportion of yolk weight to egg weight was not significantly affected in either experiment. This is in agreement with other published results (see Emmans, 1974).

Lavee (1979) has reported the results of studies in Israel where a substantial reduction in the blood supply to the ovary and digestive system was observed in birds under heat stress. A maximum reduction of 60%' of normal blood flow was observed, the extent of the reduction being proportional to the degree of heat stress. This suggests a reason for the reduction in yolk and related egg weight, but if blood flow was the only contributing factor no alteration in the relative concentrations of nutrients in the yolk would be expected. However, examination of blood plasma and eggs from laying hens acclimatised to elevated temperatures has shown a marked increase in the concentration of the B-vitamin, biotin (Table 3). This amounted to a doubling in the plasma levels of biotin in hens acclimatised to 40°C relative to control hens kept at 18°C and a doubling in the concentration of biotin in the yolks of the heat acclimatised hens compared with theirpre-experimental levels. These observations deserve further consideration, especially since trace nutrients such as vitamins are known to exert significant influences on chick viability during incubation. In particular, it would be interesting to confirm whether this increase is transitory in nature or whether it represents a stable change in the egg and plasma concentrations of this vitamin.

Conclusions

Estimates of the time required by birds to acclimatise to elevated environmental temperatures indicate that this should be predominantly complete within two weeks of the initial exposure (Hillerman and Wilson, 1954; Shannon and Brown, 1969). Therefore, the period of acclimatisation of six weeks allowed in the present studies should be adequate.

These studies, using Australian crossbred stock and simulated N.S.W. summer climate regimens, have shown that many of the responses of laying hens to elevated environmental temperatures are similar to those reported overseas. However, in many cases the quantitative effects appear to be less marked than would be suggested from overseas work at comparable temperatures. Differences in responses betweenthe two reported experimentsmay either reflect an inherent bird variability or a possible age/adaptation adjustment to the environment.

Possibly the most important factor to consider when comparing different temperature regimens is the food intake of birds, since this determines nutrient intake. In this regard the Australian White Leghorn x Australorp crossbred appears to have certain advantages over overseas stock.

References

AGRICULTURAL RESEARCH COUNCIL (1975). Nutrient requirements of farm livestock No. 1. Poultry. 2nd Edition. H.M.S.O.

BALNAVE, D. (1974). In "Energy Requirements of Poultry". P. 25. Brit. Poult. Sci. Ltd.', Edinburgh.

BALNAVE, D., FARRELL, D.J. and CUMMING, R.B. (1978). World's Poult. Sci.J. 34: 149.

BERMAN, A. and SNAPIR, N. (1965). Br. Poult. Sci. 6:207.

DOUGLAS, C.R. (1979). Proc. 35th Annual Florida Nutr. Conf. Pp. 81-87.

EMMANS, G.C. (1974). In "Energy Requirements of Poultry". P. 79. Brit. Poult. Sci.Ltd., Edinburgh.

HILLERMAN, J.P. and WILSON, W.O. (1954). Amer. J. Physiol. 180:591.

HUTT, F.B. (1938). Poult. Sci. 17:454.

KHEIRELDIN, M.A. and SCHAFFNER, C.S. (1954). Poult. Sci. 33:1064.

LAVEE, D. (1979). Poult. Intern. 18(2):68.

PAYNE, C.G. (1966). In "Physiology of the Domestic Fowl" P. 235. Oliver and Boyd Ltd., Edinburgh.

PAYNE, C.G. (1968). In "Environmental Control in Poultry Production". P. 40. Oliver and Boyd Ltd., Edinburgh.

PELL, A.S. (1978). Proc. Recent Adv. Anim. Nutr. Pp 47-56, The University of New England, Armidale, N.S.W.

SHANNON, D.W.F. and BROWN, W.O. (1969). Brit. Poult. Sci. 10:13.

SMITH, A.J. (1972a). Rhodesian J. agric. Res. 10:31.

SMITH, A.J. (1972b). Rhodesian J. agric. Res. 10:23.

SMITH, A.J. (1973). Trop. Anim. Hlth. Prod. 5:259.

SQUIBB, R.L. (1959). J. agric. Sci. (Camb) 52:217.

VAN KAMPEN, M. (1974). In "Energy Requirements of Poultry". P. 47. Brit. Poult. Sci. Ltd., Edinburgh.

WILSON, W.O. and PLAISTER, T.H. (1951). Poult. Sci. 30:625.