4.4 Discussion

Results from the current study further substantiate the findings obtained in the Field Survey (III-2.0) and Field Experiments (III-3.0) that the DRG of pigs grown in a hot climate is lower than that of animals in a thermoneutral one (Hale and Johnson, 1970). The temperature of 35°C (the current "day") is well above and 21°C ("night") is well within the thermoneutral zone of bacon weight pigs (Holmes and Close, 1977). In fact, under the current laboratory conditions the DRG of pigs in the hotroom was approximately 27% lower than that of their counterparts in the control-room (Tables 15 and 19). This reduction in DRG was presumably a result of the reduction of approximately 20% observed in DMI and 23% in EI. The fact that the reduction in DRG was about 4% greater than that in EI may have been due in part to an increased proportion of the energy ingested being used for additional physiological activities such as increased respiration rate by pigs in the hotroom (Tables 20 and 24).

Two experiments were included in the current study and it should be pointed out that Laboratory Experiment 1 was the first full test of the newly-modified climate chamber facility. During this experiment, three pigs (Nos. 3, 36 and 39 in treatments LL-Hotroom, HL-Hotroom and HL-Control-room, respectively) suffered leg injuries due to incorrect mesh-wire spacing in the floor of the feeding stalls. This problem was immediately rectified by installing new flooring and no further leg injuries were noted in this or in subsequent laboratory experiments. However, because the three injured animals were lethargic and suffered variable reduction in appetite, measurements on all parameters of them in Laboratory Experiment 1 were excluded from all analyses and a missing

values technique (Steel and Torrie, 1980) was used. Significant differences between treatments were therefore difficult to achieve.

In an attempt to simulate daily temperature fluctuations in the field, the temperature regime in the hotroom was set at 35° C by day and 25° C by night on a 12/12 hour basis. These temperatures commonly occur by day and night in commercial piggeries (see III-2.0; Field Survey), but under natural conditions the transition from night to day would have been more gradual than it was possible to simulate in the available climate chamber. Thermohygrograph records indicated that each morning in the hotroom the temperature rose from 25° C to 35° C over a period of 30 minutes. In the evenings, approximately 90 minutes was required for the temperature to fall from 35° C to 25° C as the control mechanisms did not incorporate any artificial cooling system. These rates of temperature change are more rapid than would be expected in the field, but there is no apparent reason to suppose that such differences would have influenced the relevance of the results obtained here.

A further complication introduced by the available facilities was that it was not possible to replicate simultaneously all four hotroom groups under control conditions. As the best available alternative, it was decided to include as controls only two groups on low protein diets to allow the effects of energy levels to be tested. Thus the analyses of variance were conducted in two stages; firstly as six treatment groups and secondly, as a 2 X 2 factorial design (2 diets; HL and LL X 2 environments; hotroom and control-room).

It is generally accepted that pigs eat to satisfy their energy requirement (Stahly and Cromwell, 1979) and the voluntary feed intake of an animal is known to be influenced by age and weight (Owen and Ridgman, 1968)

as well as environmental temperature (Holmes and Close, 1977). Under heat stress conditions, the intakes of protein and/or energy may thus become limiting factors due to a reduction in DMI. If such were the case, these limiting factors could possibly be overcome by increasing the nutrient density in the diet (Babatunde, Olomu and Oyenuga, 1972). Four diets with varying energy and protein levels were thus used to test this hypothesis. Although the results of Laboratory Experiment 1 (Table 17) did not reveal significant differences in either DRG, DMI or EI amongst pigs on different diets in the hotroom, those from Laboratory Experiment 2 (Table 21) did indicate that pigs on diet HH achieved higher DRG (P<0.05) than those on diets HL, LH and LL. Although there were no significant differences in EI between pigs on diets HH and HL, the fact that the DRG of pigs on diet HH was significantly higher (P<0.05) than on diet HL suggests that the low level of protein in diet HL may have become a limiting factor. The fact that pigs on diet HH, which contained more protein in relation to energy than diet HL, performed better is consistent with the existence of an "associative" dynamic effect (Seerley, McDaniel and McCampbell, 1978), by which it might be expected that these nutrients are mobilized concurrently. As expected, the EI of pigs in diets LH and LL were lower than on diet HH as a direct result of the lower energy concentration in the former diet (Fowler, McWilliam and Aitken, 1981). Increasing the protein level of low energy diets resulted in a non-significant reduction in EI (Table 21), possibly due to the fact that pigs on the high protein diet tended to eat less (Lodge, Cundy, Cooke and Lewis, 1971). Diets with a lower energy concentration in the current study tended also to have higher fibre contents (Tables 15 and 16), which in turn would be expected to be associated with lower digestibilities (Table 23, and Just, Rasmussen and

Hansen, 1976). It is known that the metabolic heat output of pigs on high fibre diets is significantly higher than on low fibre diets (Ewan, 1979; Just, 1980; Taylor and Fischer, 1960). Thus under heat stress conditions such as those experienced in the hotroom in the current study high fibre diets would be expected to increase the heat load of the animal and thus further depress voluntary feed intake.

Although no significant differences in ECR were detected in either of the current experiments when analysed on a six treatments basis (Tables 17-i and 21-i), there were significant differences in FCR in both experiments. The results indicate that pigs on diet HH converted feed more efficiently than those on the lower nutrient concentration diets. It has been shown (see Lodge *et al.*, 1971) that diets of high nutrient density have some advantages in terms of FCR but not DRG over less concentrated diets even at the same levels of energy and nutrient intake.

On a 2 diets X 2 environmental temperatures basis, both the FCR and ECR of pigs in the control-room tended to be better than those in the hotroom (Table 17-ii, P<0.05; Table 21-ii, N.S.). There are inconsistencies among the published reports (see II-3.2) on this topic which may be a function of different experimental conditions. Heat stressed pigs may require more feed or energy for maintenance to satisfy the increased in thermoregulatory requirement. Hence, the hotroom pigs might utilize feed less efficiently for maintenance and production than the control-room pigs.

The dressing percentage results from the current study support the work of Owen and Ridgman (1968) in that pigs on low energy diets had lower dressing percentages than those on high energy diets (Tables 17-ii and 21-ii). Although pigs in the control-room dressed out better than their counterparts in the hotroom, the differences were small and did not quite

reach the level required for statistical significance (0.05<P<0.10). In dressing out a pig carcase, the weight and size of the organs and their contents (e.g. gut fill) which are removed will influence the value of the dressing out percentage. Any reduction in the weight of the internal organs of heat stressed pigs (Straub et al., 1976) would have increased their dressing out percentage, and hence reduced any differences in the dressing out percentage between the hotroom and control-room pigs in the current study.

The results from the digestibility trial using Cr_2O_3 confirm that high energy diets (HH and HL) compounded for use in the current studies did in fact have higher (P<0.05) energy concentrations (DE) than the low energy ones (LH and LL; Tables 18-i and 22-i).

Although there were nominally two dietary protein concentrations (high protein and low protein) in the four diets used, there were in fact small but significant differences in the actual protein concentration between diets within each treatment protein level. These differences appeared to be largely a consequence of the decision to maintain similar energy:protein ratios (Tables 15 and 16). As a consequence within a similar dietary protein level (e.g. HL and LL; Table 18-i) the high energy diet (HL) had a higher (P<0.001) protein concentration (17.4%) than the low energy one (LL; 15.7%).

Furthermore, when analysed on a six treatments basis, the results (Table 18-i) indicated that in Laboratory Experiment 1, the DCP of diet LL (16.4%) in the hotroom was higher (P<0.05) than in the control-room (15.1%). Similarly, the ADF of the same diet (LL) in the hotroom (74.4%) was also higher (P<0.05) than in the control-room (68.6%). On the other hand, in Laboratory Experiment 2, the DCP of diet HL (14.2%; Table 22-i) in

the hotroom was lower (P<0.05) than in the control-room (15.4%). The inconsistencies in these differences have resulted in significant interactions (P<0.05) for both ADP and DCP in Laboratory Experiment 1 (Table 18-11) and for DCP only in Laboratory Experiment 2 (Table 22-11), when analysed on a 2 diets X 2 environmental temperatures basis.

There is no apparent reason why digestible protein of the same diet should be different when given to pigs in two different environments. However, **larger numbers of animals would no doubt have yielded more** accurate results. Nevertheless, the actual differences observed in DCP of the same diet for different groups of pigs in the current studies were only of the order of 1%. Such small differences in dietary protein concentration would not be expected to have differentially affected growth performance.

When the results from both experiments are compared (Tables 18-11 and 22-11), it is apparent that in the current work, temperature treatment had no significant effect on either ADM or ADF. In Laboratory Experiment 1, the differences between temperature treatments were very small indeed, though for both ADM and ADE the hotroom values were greater than control ones. It will be recalled (see page 122) that three pigs in Laboratory Experiment 1 suffered minor leg injuries, and the decision was made to exclude their results from the analyses. However, there is no reason to suppose that a minor physical injury would influence a pig's digestive function, so an additional analysis was conducted, using the actual data from these three animals rather than the missing value technique (as per the results summarized in Table 18). No changes were observed: both ADM and ADE remained only marginally higher in the hotroom than in the control-room. In Laboratory Experiment 2, on the other hand, values for both ADM and ADE were greater at 21°C (Table 22-11, 81.3 vs 80.0 and 80.9

vs 79.5% respectively), although on this occasion the differences did approach significance (both 0.05<P<0.10). This trend is consistent with the data of Holmes (1973). Furthermore, the finding that there were no significant differences in ADP due to temperature treatment in either of the current experiments supports the work of Holmes (1973, 1974).

The only significant difference observed in P2 backfat depth in Laboratory Experiments 1 and 2 was for ultrasonic measurements in Experiment 2 to be higher (P<0.05) in pigs from the control-room than those from the hotroom (Table 23-11). This result contradicts those obtained earlier under field conditions (see Field Survey III-2.0 and Field Experiments III-3.0) where P2 was measured optically. This apparently anomalous situation may have arisen because the pigs in the current laboratory studies were exposed to high ambient temperatures over a much longer period, and more regularly, than would occur under field conditions. This resulted in reduced feed intake over a long period (Tables 17-1 and 21-1) which in turn would be expected to result in a lower backfat depth (Kuan and Mak, 1982). A number of other workers (Fuller, 1965, Sugahara et al., 1970; Straub et al., 1976; Stahly and Cromwell, 1979) have also found backfat depth of pigs to be lower in a hot environment than in a cool one.

The girth of pigs in the control-room tended to be bigger than that of their counterparts in the hotroom, a result which is reflected in the significant (P<0.05) difference in chest depths (Table 19-11). Furthermore, there have been reports that pigs grown in hot climates tend to have longer legs (Fuller, 1965) and a greater carcass length (Bruner and Swiger, 1968; Stahly and Cromwell, 1979) than non-heat stressed animals. However, results obtained in the current study did not reveal any significant differences in carcass length between pigs grown at two

markedly different temperatures. This may be possibly due to the age of the experimental animals when they were exposed to the two temperature regimes. Thus the pigs which were introduced to the treatments in the current experiments at 5 months of age were perhaps too old to allow heat-induced anatomical changes to occur. Fuller (1965), Bruner and Swiger (1968) and Stahly and Cromwell (1979) detected anatomical changes when animals younger (15 days to 2 months old) than those used here were exposed to two different temperature regimes.

Physiological responses were much more pronounced than anatomical ones. In fact the RR of pigs in the hotroom was approximately threefold higher than in the control-room. Rectal temperatures were approximately $0.6-0.7° C$ higher, while skin temperatures were approximately $2.6-3.2° C$ higher in pigs in the hotroom than in controls. These results support the reports of Ingram and Legge (1972) and Marple *et al.* (1974) that RR, RT and ST become elevated when pigs are exposed to heat. Furthermore, it was found that pigs (Table 22-ii) on diet HL had higher (P<0.01) RR and ST than those on diet LL, differences which may be attributed to the higher energy intake on diet HL (Table 21-ii). An increase in energy intake is known to result in a higher rate of metabolic heat production (Close, Mount and Start, 1971) and the extra heat load experienced by the HL pigs could be expected to elevate their rectal and skin temperatures.

The overall results from these two laboratory experiments indicate very clearly the extent to which the performance of growing pigs may be reduced by the imposition of high environmental temperature. This was due largely to a reduction in voluntary feed intake under heat stress conditions. Growth performance may be improved, as demonstrated by the results of these two experiments, by increasing both the energy and protein concentrations

in the diet. Heat stressed pigs must derive their nutrient requirements from a relatively low volume of feed and it is evident that the accepted nutrient concentrations may be inadequate at elevated temperatures. The dietary protein levels suggested in the current experiments, 17 to 20%, were similar to that recommended by Babatunde, Olomu and Oyenuga (1972) for pigs growing in a tropical environment. These levels of dietary protein are much higher than the ARC (1967) recommendations. The dietary energy level suggested here was between 14.0 and 19.0 MJ/kg DM, which is higher than the ARC (1967) recommendation of 14 MJ/kg DM. The increases in both dietary energy and protein level are designed to obtain an optimum energy-protein ratio (Crampton and Harris, 1969) for high temperature conditions. The ratio for the HH diets used in both experiments here was 1:1.2 (MJ/kg DM:% DCP). Unfortunately the lack of available pen-space precluded study of this aspect in the current work and further laboratory and field experiments will be required to detect possible ambient temperature effects on the optimum energy and protein level and energy:protein ratio.