
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

THE APPLICATION OF PERFORMANCE TESTING TO PIG IMPROVEMENT IN NEW ZEALAND

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SUMMARY

Performance testing is discussed with particular reference to the boar testing facilities existing in New Zealand and the structure of the local pig industry. The present boar testing procedure is described. Data accumulated during five years of testing are used to illustrate and assist the discussion. It is concluded that a national pig breeding plan which makes full use of existing facilities can be formulated and should be implemented.

AN ANIMAL can be assessed on the basis of its own individual productive performance. The objective of such an assessment or performance test is usually to make some estimate of the genetic merit of the individual relative to other defined individuals. It is generally agreed that the combination of performance testing and selection offers the quickest and cheapest means to genetic improvement of pigs for post-weaning growth and carcass traits (P.I.D.A., 1965). The confusing variation introduced into the testing system by differences in climate, housing, feeding and general animal care can be reduced or allowed for in a number of different ways. The New Zealand Pig Producers' Council have chosen to test boars in a standardized, common environment. A national test centre was built in the Waikato and the first intake of boars entered the centre in January, 1965. The genetic improvement which can be made nationally depends upon the testing system and the use to which tested animals of superior merit are put in the overall breeding plan. The objective of this paper is to discuss central performance testing and its national usefulness.

TESTING PROCEDURE

An entry consists of a pair of boars which may be paternal half-sibs or full-sibs. Boars must be from litters containing 8 pigs reared (7 if a maiden litter) and must have reached a minimum weight of 15.9 kg (35 lb) at 8 weeks of age. Each boar is expected to be between 18.1 kg

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(40 lb) and 22.7 kg (50 lb) on arrival at the centre. The minimum weight provision was introduced in order to reduce the possible effects of compensatory growth. Good health and freedom from defects are required. Prior to commencement of the test, the pigs are treated for internal and external parasites and given a three-day, high level course of antibiotics. Each pair of pigs is housed separately and precautions are taken to minimize cross-infection between pens and the introduction of infection from outside. Entries are now accepted on a continuous basis with an endeavour being made to keep the 20 pens (40 boars) filled. The additional disease risk of this system over a group entry system is the cost associated with maximum usage of the facilities.

Boars are actually on test from 27.2 kg (60 lb) liveweight to 81.6 kg (180 lb) liveweight. They are weighed weekly and rationed according to liveweight. Total food intake is measured for each boar fed individually twice daily. The high quality ration consists of 40% barley meal, 40% maize meal, 20% buttermilk powder, copper sulphate at 250 ppm and other vitamin and trace mineral additives. Note that this is not a commercial ration and that boars are fed on a restricted but liberal scale to a final weight acceptable to the meat trade.

TRAITS RECORDED

In pig production there are essentially three distinct complexes of traits; the growth rate-efficiency complex, the fatness-meatiness complex, and the sow productivity-reproduction complex. It seems clear that in pig improvement it is necessary to select for at least one trait from each of the first two complexes and in these circumstances some form of index is desirable. Even a crude index such as, for example, a total score will be more efficient in terms of selection for overall merit than selection for one complex at a time (tandem method) or setting independent culling levels.

The traits chosen for presentation to breeders are average daily liveweight gain over the test weight range (DG), the ratio of average daily food intake to average daily gain (ER), and an estimate of mean backfat thickness (BF). The latter is calculated from measurements made at the final weight using an ultrasonic device 3.8 cm (1.5 in.) off the midline at the shoulder, last rib and loin. In calculating the mean, double weight is given to the last rib measurement. All three traits fulfil the criteria of being measurable on the live male, reasonably highly heritable, variable enough to make effective selection possible, and of real economic importance.

The ratio (ER) as a measure of efficiency is directly proportional to total food intake. With the test conducted over a constant weight range and food offered (but not necessarily consumed) being directly related to liveweight, gain is inversely and efficiency directly proportional to the number of days on test. Under these conditions, the correlation between these two traits might be expected to approach −1. When the breeding policy calls for increased total meat production under restricted feeding, daily gain is probably the most direct measure of productivity. Research has consistently shown high correlations between liveweight gain to market weights of round 90 kg and various measures of efficiency (see for example Smith *et al.*, 1962; Smith and Ross, 1965). The correlation is likely to be lower under *ad lib.* feeding regimes because of the increase in variability of food intake and this has been confirmed by Owen and Morton (1969). It is therefore much more important to measure food intake under *ad lib.* systems than under restricted systems and, since the former are likely to become increasingly important commercially for economic reasons, a change in the testing system to *ad lib.* feeding may be warranted in the future.

Backfat thickness is economically important in pig production as an indicator of carcass composition. It seems clear that future grading schemes will penalize fat pigs. The backfat thickness at market weight can be reduced if feeding is restricted and the growing period lengthened. However, this is uneconomic when high quality, expensive rations are used. Hence it is necessary to consider backfat in any testing and breeding scheme.

All three traits defined above have been included in the current index. No claim is made that this is the best possible index but it is more sophisticated, and probably more useful, than a total score. It was constructed using standard index techniques (Hazel, 1943) and available estimates of the various parameters. The values used are given in Table 1.

The index is $I = [4(\mathrm{DG}) - 2(\mathrm{ER}) - (\mathrm{BF}) + 5]\ 100$

Gain is given in pounds, backfat in ultrasonic units. Over the scale range involved, one ultrasonic unit equals 3.33 mm.

The relative economic values given in the table are somewhat arbitrary. Even with a grading system based largely

TABLE 1: STATISTICS USED IN THE CALCULATION OF THE CURRENT BOAR TEST INDEX

Trait	*S.D.*	*Heritability*	*Relative Economic Value*	*Correlations** *DG*	*ER*	*BF*
DG	0.1	0.3	10		—0.6	0.1
ER	0.1	0.3	—10	—0.6		0.3
BF	0.3	0.3	—2	0.0	0.2	

*To right of diagonal — Phenotypic. To left of diagonal — Genetic.

on backfat thickness this trait is difficult to value. A certain minimum backfat is required so that desirably the emphasis placed on this trait should decrease as backfat thickness decreases. A method for dealing with this problem using a quadratic model has recently been proposed by Wilton *et al.* (1968).

It is virtually impossible to allocate separate values to two traits as closely related as gain and efficiency and it can be argued that there would be little loss of information if ER were eliminated from the above index. Naturally the fewer independent traits included in a selection programme the greater can be the selection intensity for each. However, it is likely that gain and efficiency are highly correlated phenotypically, and both traits can be included in the index without reducing the possible selection pressure on either one by very much. The inclusion of both traits can be justified on the grounds that both have meaning, and are important to pig producers. It should be noted that the relative weightings placed on the two complexes mentioned earlier are affected by the inclusion of both traits.

ALLOWANCE FOR ENVIRONMENTAL CHANGES

Although the boar test centre represents a standardized, common environment, the environmental components of performance can still change with time. Hence the need for a statistical procedure such as the comparison of boars with contemporary test mates to reduce the influence of these components in the published test result. With the adoption of a continuous entry system it became necessary to decide what boars should be included in a contemporary average. The more pigs included in the calculation of the average the better the estimate but the longer any one pig is included. As a compromise, it was decided to employ a 30 pig rolling average with one-third of the pigs being changed as each 10 complete test. In theory this means that no pig is included in the average for longer than about three months (in practice this period has been longer because the centre has not been filled to capacity). This average is actually the average of 30 pigs tested in the immediate past rather than a true contemporary average. The avérage index score is subtracted from the index score of each individual boar and the result for the individual is converted into a rating. The ratings range from -5 to $+5$ on a discontinuous scale. At present, any boar with a rating of -3 or less is automatically culled unless he is of one of the coloured breeds (Tamworth, Berkshire, Saddleback).

Initially the average fluctuated more widely than anticipated. Because of the scaling involved, the index is sensitive to quite small changes in the values of the components and the average can be changed markedly by the performance figures of boars added to and eliminated from it. An analysis has been made of the records of the 170 boars indexed since adoption of the present system. The 15 different averages range from 91 to 200 with no evident time trends. All boars, regardless of breed and breeder, are included in the average. It is quite clear from an examination of the data that the two major factors determining the level of the average at any one time are the ratio of Large Whites to Landraces and that of National Pig Breeding Centre boars to those of other breeders. The number of pigs of other breeds (9) has been too small to be of much influence.

Results from a least squares analysis of data from the 161 Large White and Landrace boars are given in Table 2. Significant breed differences are present for all traits ex-

TABLE 2: MEANS OF FIVE TRAITS FOR LARGE WHITE AND LANDRACE BOARS OF TWO ORIGINS

Breed and Breeder	*No.*	*DG kg (lb)*	*ER*	*BF (cm)*	*Index*	*Rating*
Large White:						
National	37	0.88 (1.95)	2.44	1.84	230	+ 2
Other	58	0.85 (1.87)	2.53	1.97	150	+ 1
Landrace:						
National	20	0.84 (1.85)	2.64	1.85	157	— 1
Other	46	0.83 (1.83)	2.55	1.95	134	— 1

cept backfat thickness and significant breeder differences for all traits except efficiency. There is a significant breed × breeder interaction for efficiency which can be seen readily in the table. In general, Large Whites are superior to Landraces in growth traits. The general superiority of National boars over those of other breeders is due presumably to the long-term policy of objective recording and selection carried out in the National herd. It can be seen how the relative proportions of boars of the different classes could affect the average index. There are several possible solutions to the fluctuating average problem but, since the composition of the throughput, and hence the average index, has recently settled down, a "wait and see" policy has been adopted.

CORRELATIONS

Correlations among the traits, calculated in the above analysis within breed-breeder subclasses, are set out in Table 3. These correlations are essentially similar for the two breeds when these are examined separately. The high

TABLE 3: CORRELATIONS AMONG THE TRAITS WITHIN BREED-BREEDER SUBCLASSES

161 Large White and Landrace Boars

	ER	*BF*	*Index*	*Rating*
DG	—0.74	0.19	0.65	0.62
ER		0.00	—0.66	—0.63
BF			—0.56	—0.52
Index				0.94

correlation between gain and efficiency is as expected but falls short of perfection mainly because boars do not always eat all of their ration at each feed and because the scale of feeding is changed weekly rather than daily. The correlations between the gain-efficiency complex and backfat thickness are small, justifying the use of at least one of the former traits with the latter in an index of overall merit. The three primary traits are all highly and equally correlated in the right direction with the index and rating.

EARLY CULLING

The method of setting independent culling levels for two traits has merit when traits are expressed at different times and preliminary culling can be done on one trait before the other is measured. The partial culling of boars at a lighter weight than the present final weight could increase the throughput of boars, reduce the cost of testing per boar, and possibly increase the salability of cull boars. Brown (1967) has discussed the use of correlated variables for preliminary culling in terms of the reduction in selection differential resulting from imperfect correlation. Given an arbitrary permissible level of decrease in differential, a known correlation and the proportion of the population it is desired be retained, it is possible to determine the level of preliminary culling.

Data were available from 76 boars measured at 49.9 kg (110 lb) as well as at 81.6 kg. Within test group correlations between traits measured to or at the lighter weight and the equivalent traits at the heavier weight were found to be 0.49, 0.36 and 0.47 for gain, efficiency and backfat, respectively. Assume 30% of all boars tested are to be retained. The expected selection differential in standard deviation units is 1.16 for a normally distributed variate with truncation selection. If a reduction of 0.06 is considered allowable, then, with a correlation of 0.4, it can be seen from Brown (1967) that 25% of the population can be culled on the correlated variate at the lighter weight. A selection differential of 1.10 would be obtained by retaining 33% of the population and with all culling done at the heavier weight. Unfortunately, with physical limitations of the present boar test centre, both boars of a pair would need to be culled at the lighter weight in order to free a pen for a new entry. Nevertheless, preliminary culling of the order of 25% could allow the testing of 10 to 15% more boars in a given period of time.

Effective performance testing means that a large number of entire boars must be grown to market weights and effective selection means that most of these must be sold for meat. If there were no market discrimination against boars, then performance testing on the farm and centrally would become a much more attractive proposition to breeders. Comprehensive reviews of the advantages of boars over castrates and the problem of "boar taint", the odour sometimes produced when the fat of entire mature boars is cooked, have appeared recently (Walstra and Kroeske, 1968; Wismer-Pedersen, 1968; Martin, 1969). It seems that the risk of taint is small in boars up to about 70 kg liveweight and that lightweight boar carcasses could be marketed without difficulty. It is in the higher weight ranges that the main advantages of boars in terms of lean meat and efficiency appear and the advantages of raising boars to about 50 kg in order to increase the possible selection intensity do not seem to have been generally appreciated.

APPLICATION TO THE INDUSTRY

The distribution of boars according to rating is shown in Fig. 1 and this distribution approaches the normal. There is no evidence of kurtosis and, although there is a tendency towards negative skewness, the estimate of the third moment statistic is not significantly different from zero in this sized sample. It can be seen that there have been only two + 5 and seven + 4 boars since the rating system was introduced. This small number could easily be lost through leg faults or accident. With a large number of independent breeders using the facility, the chances of an individual breeder getting even one exceptional boar in five years is small, even if the centre is kept full to capacity. Probably the main reason for advocating large size breeding operations with large-scale testing is to increase the chances of discovering a sufficient number of outstanding individuals among those tested. This has recently been pointed out by Watson (1968) and discussed theoretically by Fredeen and Martin (1967). The second

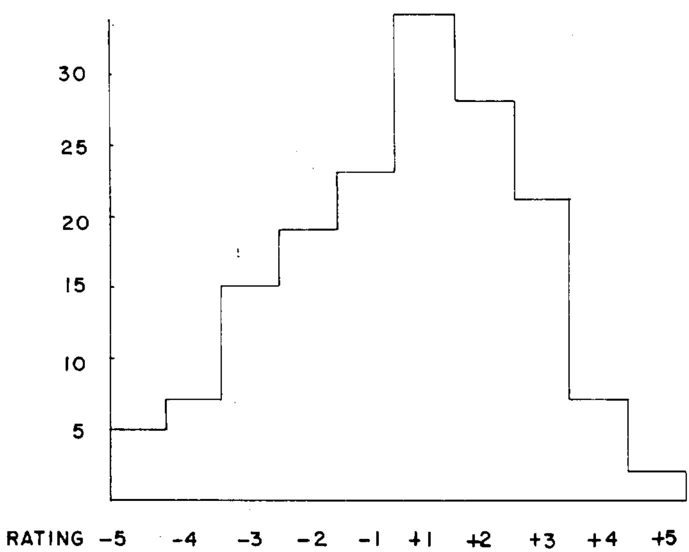

FIG. 1: *Distribution of Large White and Landrace boars by rating (161 boars).*

and more commonly stressed reason for advocating size is the avoidance of inbreeding which becomes important in herds of size less than about 30 sows and 6 boars.

Size can be achieved in several different ways and with different performance testing schemes integrated into the overall breeding plan. In New Zealand there is the problem of fitting a breeding plan incorporating the necessary scale of operations into an existing performance test set-up which has cost money to initiate and is a going concern. The test centre is itself of limited size. There are a few breeders with herds large enough to operate as closed breeding units giving the opportunity for independent breeding schemes using testing on the farm. These need not be discussed here although they are of great importance nationally.

The majority of breeders have small herds in the region of 10 to 15 sows of any one breed. It is specifically to assist these breeders and enable them to participate in larger operations without losing their identities that the Technical Committee of the New Zealand Pig Producers' Council advocates closed, co-operative breeding schemes. Such schemes can make use of the national test centre and simplified on-the-farm testing of gilts and potential sale boars. They are based on the following principles:

(1) Regularity and continuity of testing by participants.

(2) Maintenance of an adequate selection differential among tested boars.

(3) Primary attention given to a few traits of high heritability and real economic importance.

(4) As short a generation interval as is physically and economically possible.

While the idea of co-operatives has not been adopted by the industry at large, the Council has recently made a gesture towards continuity of testing by introducing a clause giving preference to the sons of tested and selected boars in entry to the test centre. It is desirable that the central test centre will always be open to independent breeders following constructive breeding plans so that buyers of breeding stock can evaluate the relative merits of different herds. What constitutes an adequate number of pigs to test for this purpose remains a problem.

It is necessary to keep a check on the commercial performances of the progeny of superior tested boars. It is assumed that the progeny of boars with outstanding performances on the test centre ration will perform above average on a variety of commercial rations, but research data are lacking. This problem is discussed in the P.I.D.A. (1965) report.

Essentially I envisage the few large herds and the co-operatives acting as nucleus herds in a breeding scheme embracing the greater part of the national industry. Multiplier herds supplying boars to commercial farmers will obtain all of their boars from the nucleus herds and thus improve at the same rate as the latter but lagging two generations behind (Smith, 1960). Such a national plan can be formulated to make full use of existing facilities and should be implemented without delay.

ACKNOWLEDGEMENTS

I wish to acknowledge the encouragement of members of the New Zealand Pig Producers' Council, the work and ideas of members of the Technical Committee, and especially the help of T. Hope, Manager of the National Breeding Centre and the Test Centre. The technical assistance of staff in the Genetics Section, R.A.R.C., in the data analyses is also gratefully acknowledged.

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