may be rather large differences in the maternal influence of the three pure breeds for feedlot performance and carcass traits.

Another important question is whether reciprocally produced crossbred females differ in their maternal influence for these traits and also the relative importance of the maternal heterosis of the crossbred dam. However, more data are needed before any definite conclusions can be made.

Swine Crossbreeding Results: 2-Breed Crosses vs. Purebreds

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Story in Brief

The reproductive performance for 440 Duroc, Hampshire and Yorkshire dams, the feedlot performance for 941 pigs, and the carcass data on 190 slaughter pigs were used to evaluate the influence of using a boar of a different breed on purebred females. Yorkshire females had a higher reproductive failure rate than Durocs or Hampshires, and Hampshires had a lower ovulation rate than Durocs or Yorkshires. Productivity of Durocs and Hampshires was increased by mating them to a boar of a different breed, but crossbreeding had negligible influence on the productivity of Yorkshire females. However, the purebred Yorkshire litters were larger and heavier than crossbred litters produced by Durocs and Hampshires.

Overall, purebred sows with crossbred litters showed an advantage of 7.4 percent more pigs at farrowing, 16.1 percent more pigs at weaning,

In cooperation with USDA Agricultural Research Service, Southern Region.

17.5 percent heavier litter weaning weights and 12.1 percent higher pre-weaning pig livability over purebred sows with purebred litters.

Crossbred pigs reached market weight 10 days earlier and consumed 5.7 percent more feed per day than purebreds. Differences in feed efficiency between purebreds and crossbreds were negligible, but purebred Yorkshire pigs tended to be most efficient.

Breed differences were noted in backfat thickness, lean yield and meat quality; but purebred performance tended to be a good predictor of crossbred performance. Hampshires had less backfat thickness and higher lean cut yield, but had lower muscle quality scores than the other two breeds. Hampshire-Yorkshire crosses revealed negative heterosis since they were fatter, had lower lean cut yields and lower muscle quality scores than the average for the purebreds making up this cross. When Durocs were used in the cross, there was a marked increase in quality over crosses which did not involve Durocs.

Introduction

Crossbreeding is widely used in the livestock industry to capitalize on the desirable characteristics of different breeds and to obtain increased performance in the crossbred individual over the average of the parent breeds making up the cross (heterosis). Although a high percentage of the hogs marketed in the United States are of crossbred origin, breeders do not have sufficient data available to know which crosses yield best results.

This study was initiated in 1969 at the Oklahoma Experiment Station to evaluate the overall combining ability of Durocs, Hampshires, and Yorkshires and to determine the relative amount of heterosis achieved for all economically important traits. The results presented in this paper deal with the first phase of the project where the influence of using a boar of a different breed on purebred gilts is evaluated.

Materials and Methods

The purebred seedstock herds for this project are maintained at Stillwater with the evaluation herds maintained at the Ft. Reno Experiment Station. An attempt is made to maintain a relatively broad genetic base in each of the seedstock herds and to keep inbreeding to a minimum. Two new unrelated boars are purchased for each herd each year, and three boars are kept over for another breeding season.

In the fall of 1969, the 3 purebred seedstock herds were formed by obtaining about 25 gilts and 5 boars for each herd. The initial breeding stock came from as many different lines of breeding as possible within

each breed. From the purebred litters produced at Stillwater in 1970 spring, 54 gilts and 6 boars from each breed were selected after they completed a feeding test and taken to Ft. Reno for breeding in 1970 fall. Each boar was mated to 3 gilts of his own breed and to 3 gilts from each of the other two breeds.

Approximately 30 days after breeding, one gilt from each mating type for each boar was randomly selected to be slaughtered to evaluate ovulation rate and early embryo development. The other 2 gilts from each mating type for each boar were carried full term and permitted to farrow. During the first season this system resulted in 45 gilts slaughtered for reproductive tract studies and 88 gilts farrowed. This procedure was again repeated six months later with a new group of boars and gilts from the Stillwater herd, and 74 gilts were slaughtered one month after breeding and 87 were permitted to farrow.

Approximately one-half of the females farrowing during the second season were sows and their records were adjusted over all breed groups to a gilt equivalent basis with a least squares additive correction factor. Because of management problems in the fall 1971 farrowing season, excessive post-farrowing death losses occurred, and the females that farrowed in that season were remated in late winter to farrow in summer 1972. These sows were randomly mated in the same manner as described for the other seasons to a new group of young boars of each breed from Stillwater. No sows were slaughtered, and 69 litters from this season were included in the analyses. All pigs from these summer litters were sold after weaning.

All sows in this study farrowed in confinement and each sow and litter was penned separately until the pigs were weaned at 42 days of age. Pigs were given access to creep feed after the 21-day weights were obtained. Two weeks after weaning, the pigs were moved to the confinement finishing barn and allotted by breed in groups of about 16 pigs per pen. The pigs were given one week to get adjusted to their new surroundings before being weighed on test.

All pigs were self-fed a 16 percent crude protein ration until they reached 220 lbs. Pigs were weighed off test on a weekly basis as they weighed 220 lbs., and all gilts were probed for backfat thickness at that time. The postweaning feeding tests included the performance on a total of 941 pigs and feed records on 63 pens. Probe backfat measurements were taken on 479 gilts. About 10 barrows per breed group were taken to the University Meat Laboratory and slaughtered for carcass cutout and muscle quality data. A total of 190 carcasses were evaluated in this study.

Results

Reproductive Efficiency

The breeding performance for the 440 females selected for the breeding herd is summarized in Table 1. In this project, estrus was detected with the assistance of a teaser boar, and hand mating was used in all seasons. Gilts were between 210 and 270 days of age at the beginning of the breeding season, and the breeding season was long enough to permit problem breeders to have at least 3 complete estrous cycles. Overall, 59 of the 440 females (13.4 percent) failed to conceive. The percentage of failures for Durocs, Hampshires, and Yorkshires were 10.1, 6.8 and 23.4 percent, respectively, with Yorkshires having a significantly higher failure-rate than the other two breeds.

Since the reproductive failures among Yorkshires were also greater than the failure-rates for Duroc and Hampshire sows, the observed breed differences could not be due to differences in sexual maturity at breeding. Part of the difference could be attributed to the fact that the visual signs of estrus are less vivid among Yorkshire females, and therefore, a higher percentage were not observed in heat when they actually would have accepted a boar under a natural mating system.

Table 1. Reproductive Efficiency and Ovulation Rate by Breed of Sow

	Breed of Dam		
	Duroc	Hampshire	Yorkshire
Reproductive Efficiency:			
Gilt Data:			
No. selected for breeding	100	100	101
No. pregnant at end of season	93	94	77
No. failing to reproduce	7	6	24
Failure rate, %*	7.0	6.0	23.8
Sow Data:			
No. selected for breeding	49	46	44
No. sows that farrowed	41	42	34
No. failing to farrow	8	4	10
Failure rate, %*	16.3	8.7	22.7
Overall:			
Total no. selected for breeding	149	146	145
No. pregnant at end of season	134	136	111
No. failing to reproduce	15	10	34
Failure rate, %*	10.1	6.8	23.4
Ovulation Rate for Gilts Slaughtered:			
No. gilts slaughtered	43	40	36
No. corpora lutea per gilt*	13.8	12.1	13.8

*Indicates that breed difference was significant ($P<.05$).

Ovulation Rates and Early Embryo Development

As shown in Table 1, Duroc and Yorkshire gilts ovulated more eggs than Hampshire gilts. The embryo data presented in Table 2 shows that purebred Duroc and Hampshire gilts tended to have more developing embryos when mated to a boar of a different breed, but the number of developing embryos for Yorkshire gilts was about the same whether they were carrying purebred or crossbred embryos. Overall, gilts with crossbred litters had a higher proportion of the eggs ovulated represented as live embryos when slaughtered at 30 days postbreeding, but this advantage was primarily due to the higher percentages obtained for crossbred litters in Durocs and Hampshires.

These data show no advantage for using a boar of a different breed on Yorkshires but considerable advantage for the other two breeds. Crossbred embryos were not consistently larger than purebred embryos in this study, but Hampshire and Duroc gilts tended to have larger embryos than Yorkshire gilts.

Litter Production Records

The litter records are summarized in Table 2. Purebred dams of all breeds with crossbred litters farrowed and raised more pigs per litter than did purebred dams with purebred litters resulting in an overall increase in litter size of 0.7 pigs at farrowing and 1.0 pig at weaning. This advantage was most pronounced among Duroc dams at farrowing and both Duroc and Hampshire dams showed a definite advantage for number of pigs raised when the litter was crossbred. Yorkshire females weaned the largest litters and using a boar of a different breed did not have any marked effect on their productivity. The greatest increase in livability (19 percent) due to crossing was noted among Hampshire dams with Durocs revealing a somewhat smaller increase (5.3 percent), and Yorkshires showing virtually no difference between purebred and crossbred litters.

Breed of dam differences for litter traits through weaning were apparent. Both Duroc and Yorkshire dams farrowed larger litters than Hampshires while at 42 days Yorkshire dams had larger litters than either Duroc or Hampshire dams, while the 0.4 pig per litter difference in litter size of Duroc and Hampshire dams at 42 days was not significant. Overall, Yorkshire dams raised 13 percent more of their pigs from birth to weaning.

Pigs from Yorkshire dams weighed less at birth than those from Duroc and Hampshire dams. However at 21 days of age, pigs from Yorkshire dams were the heaviest even though they were also from larger litters. This suggests that Yorkshire dams not only were better mothers

Table 2. Reproductive Performance of Purebred Sows with Crossbred Litters Compared to Those with Purebred Litters

	Duroc Sows		Hamp Sows		York Sows		Overall		% Improvement
	Pure	Cross	Pure	Cross	Pure	Cross	Pure	Cross	over Purebreds
Early Embryo Development:									
No. gilts slaughtered	13	30	14	26	12	24	39	80	
No. embryo per gilt*	10.6	11.1	8.6	9.9	11.4	11.3	10.2	10.7	4.9
% embryos of eggs ovulated*	74.2	81.9	74.5	82.3	83.9	83.1	77.6	82.5	6.3
Embryo size, mm.	24.5	25.2	26.0	25.3	23.3	24.4	24.6	25.0	1.6
Litter Records:									
No. litters	31	53	32	58	23	47	86	158	
No. pigs farrowed/litter*	9.5	10.6	8.9	9.4	10.2	10.7	9.5	10.2	7.4
Avg. pig birth wt., lb.	2.9	2.8	2.7	2.8	2.4	2.4	2.7	2.7	0
Avg. pig 21-day wt., lb.	9.6	10.2	10.4	10.7	10.8	10.5	10.3	10.5	1.9
Avg. pig 42-day wt., lb.	22.9	23.3	21.8	23.2	24.3	23.4	23.0	23.3	1.3
No. pigs raised/litter*	5.7	7.0	5.2	6.7	7.7	8.0	6.2	7.2	16.1
Litter 42-day wt., lb.*	130	163	113	155	187	187	143	168	17.5
% survival*	61.0	66.3	54.6	73.6	77.4	76.5	64.3	72.1	12.1

*Indicates that difference observed between purebreds and crossbreds was significant ($P \leq .05$).

in terms of keeping their pigs alive but also provided a larger supply of milk per pig than did Duroc and Hampshire dams. The fact that the differences between 42-day pig weights were small suggests that the creep feed being fed from 21 to 42 days of age tended to compensate for milk production and perhaps masks breed differences in maternal ability from 21 to 42 days.

Although the differences in number of embryos 30-days postbreeding among purebred litters and crossbred litters for each breed of dam were not significant, they were used in the same direction and of approximately the same magnitude for each breed of dam as were the traits from birth to weaning. This lends further support to the idea that dams of these three breeds will exhibit a defferent response to crossbreeding in litter size.

None of the differences between average pig weight per litter for purebreds and crossbreds in this study were significant and all did not favor crossbreds. On the average, crossbred pigs and purebred pigs weighed the same at farrowing, but crossbred pigs averaged 0.3 lb. heavier than purebreds at weaning. This represents a relatively small increase of 1.34 percent in average pig weight per litter for crossbred litters over purebred litters. However, crossbred litters weighed 25 lbs. more than purebred litters at weaning yielding an increase of 17.5 percent.

These data suggest some response to crossbreeding in early embryo development; however, the primary response to crossbreeding appears to be in ltiter size at birth and weaning and a greater survival rate for crossbred pigs than for purebred pigs. It appears that this response is due primarily to an increased livability throughout gestation and from birth to weaning in crossbred litters produced by Duroc and Hampshire dams with little, if any, difference in livability between purebred and crossbred litters from Yorkshire dams. Other factors such as increased fertilization rate or implantation rate when using a boar of another breed on Duroc and Hampshire dams may also be important; however, these data are insufficient to determine the reason for the differential response of breeds.

Growth Rate and Feed Efficiency

The feedlot results are summarized in Table 3. Crossbred pigs gained 0.14 lb. per day faster than purebreds during the postweaning period and reached 220 lbs. in average of 10 days less time. In all cases the crossbred pigs gained significantly faster than the average of the purebreds making up the cross (this is heterosis). Purebred Durocs tended to gain faster than purebred Hampshires and Yorkshires, but none of the differences were significant except for Durocs reaching 220 lbs. at an

earlier age than Hampshires. When Durocs were involved in the cross, the pigs tended to grow faster than when Durocs were not used in the cross.

Crossbred pigs consumed an average of 5.7 percent more feed per day than purebreds. Purebred Yorkshires had the lowest daily consumption and the most desirable feed efficiency. Overall, there was essentially no difference in the feed efficiency of purebreds and crossbreds.

Probe Backfat Thickness of Gilts

Although there was no marked difference between the fatness of purebreds and crossbreds, some differences between breed groups were noticed. Durocs were fatter than Hampshires and Yorkshires. Duroc-Hampshire crossbreds had 0.05 in. less backfat than the average of the purebred Durocs and Hampshires. Crosses involving Durocs tended to be fatter than when Durocs were not used in the cross.

Carcass Tracts

The data for the 190 carcasses evaluated are shown in Table 4. Rather large differences among purebreds were noted, but the differences between purebreds and crossbreds tended to be relatively small. Durocs were shorter than Hampshires and Yorkshires, however Hampshires had less backfat than Durocs and Yorkshires and exceeded them in loin eye area and yield of lean cuts. There was little difference between purebred Durocs and Yorkshires for these traits.

Each of the quality scores of marbling, firmness, and color ranked in the order of Durocs, Yorkshires, and Hampshires. Differences between Durocs and Hampshires were significant for all three traits while the differences between Durocs and Yorkshires were significant for marbling and firmness scores. Yorkshires also had higher firmness and color scores than Hampshires.

In general, the average of the purebreds making up the cross was a good predictor of the crossbred carcass merit. However, Duroc-Yorkshire crosses were longer than the average of the breeds making up that cross, and Hampshire-Yorkshire crosses tended to be fatter and have a lower lean cut yield than the average for purebred Hampshires and Yorkshires.

All crosses involving Durocs resulted in rather large positive heterosis for marbling and firmness scores; however, there was negative heterosis for these traits in Hampshire-Yorkshire crosses. There was considerable variation among crosses in the amount of heterosis expressed for color score; however, the difference between crossbreds, and purebreds was significant only in the Hampshire-Yorkshire cross.

Table 3. Postweaning Performance and Probe Backfat Data for Purebreds Compared to 2-Breed Cross Pigs.

	Purebreds			2-Breed Crosses			Overall		% Improvement over Purebreds
	Durocs (D)	Hamps (H)	Yorks (Y)	DxH	DxY	HxY	Pure-breds	Cross-breds	
Growth Rate:									
No. pigs	85	65	79	234	270	208	229	712	
Daily gain, lb.*	1.48	1.45	1.44	1.61	1.62	1.58	1.46	1.60	10.2
Days to 220 lbs.*	187.0	192.7	189.1	179.7	178.2	181.0	189.6	179.6	5.3
Feed Records:									
No. pens	7	7	9	12	15	13	23	40	
Feed/pig/day, lbs.*	5.23	4.90	4.59	5.46	5.08	4.99	4.90	5.18	5.7
Lbs. feed/lb. gain	3.34	3.27	3.11	3.33	3.15	3.17	3.24	3.22	0.6
Probe Backfat Data:									
No. gilts	50	38	53	111	130	97	141	338	
Backfat thickness, in.	1.38	1.16	1.19	1.22	1.25	1.20	1.24	1.22	1.6

*Indicates that difference between purebreds and crossbreds was significant ($P<.05$).

Table 4. Carcass Cutout Data for Purebreds Compared to 2-Breed Crosses

	Purebreds			2-Breed Crosses			Overall		% Improvement over Purebreds
	Durocs (D)	Hamps (H)	Yorks (Y)	DxH	DxY	HxY	Pure-breds	Cross-breds	
No. carcasses	22	23	22	40	41	42	67	123	
Carcass length, in.	30.1	30.7	30.8	30.5	30.8	30.8	30.5	30.7	0.6
Carcass backfat, in.	1.26	1.06	1.24	1.20	1.20	1.22	1.19	1.21	—1.9
Loin eye area, sq. in.	4.84	5.22	4.70	4.96	4.77	4.86	4.92	4.86	—1.2
% lean cuts of carcass wt.	54.9	58.5	56.1	56.5	56.0	56.4	56.5	56.3	—0.4
Ham-loin index	95.6	108.4	97.3	101.1	97.7	99.1	100.6	99.3	—1.3
Carcass quality:[1]									
Marbling score*	5.6	3.1	3.7	5.5	5.3	2.8	4.1	4.6	10.7
Firmness score	5.9	3.8	4.7	5.6	5.6	3.7	4.8	5.0	4.4
Color score	5.3	4.4	5.1	5.2	5.2	4.3	4.9	4.9	0

[1] Loin quality at 10th rib was evaluated using a 7-point scoring system; 1=devoid of marbling, very soft and pale; 5=average marbling and firmness and dark pink color; 7=abundant marbling, very firm and very dark.
*Indicates that differences observed between purebreds and crossbreds was significant ($P<.05$).

These data tend to support the conclusion that there is little heterosis for carcass traits and that the average crossbred performance for most traits can be predicted quite well from the average of the purebreds which made up the cross. There appears to be considerable heterosis expressed for carcass quality; however, the amount and direction seem to be dependent on the specific cross involved.

With the exception of carcass length and the quality scores, none of the differences between the crossbred averages were significant. Duroc-Hampshire crosses were shorter than both Duroc-Yorkshire crosses and Hampshire-Yorkshire crosses. When Durocs were used in the cross, there was a marked increase in quality score over crosses which did not involve Durocs.

Additional studies involving greater numbers and more sire groups are needed before any conclusions can be made regarding differences between reciprocal crosses. The limited data available indicates that there may be some real differences in pig performance and carcass traits for pigs of the same breed composition depending upon which breed serves as the sire and which breed serves as the dam. Additional research is underway at the present time to further evaluate this difference.
