AGONISTIC BEHAVIOUR IN FINISHING PIGS (*SUS SCROFA*) FOLLOWING MIXING: ITS EFFECTS ON PRODUCTIVITY

by

SHENTON S.L. TAN

B.Sc. (Agr.), The University of British Columbia, 1983

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE STUDIES

(Department of Animal Science)

We accept this thesis as conforming

to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

January 1988

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Animal Science

The University of British Columbia
1956 Main Mall
Vancouver, Canada
V6T 1Y3

Date February 29, 1988

DE-6(3/81)

ABSTRACT

The effect of mixing unfamiliar finishing pigs (*Sus scrofa*) on agonistic behaviour and productivity over a 3 week period was investigated. Nine groups of six pigs were allocated to one of three treatments and eight groups of six pigs to the fourth treatment. In the first treatment (unmixed) littermate groups were moved into a new pen and in the second treatment (3:3 mixed) 3 pigs from one littermate group were mixed with 3 pigs from a second littermate group. The third treatment (Stresnil-treated) was similar to the second treatment but pigs were injected with the tranquilizer Stresnil (azaperone) prior to mixing. In the fourth treatment (5:1 mixed) groups of five pigs were introduced into a pen already occupied by either a single relatively light weight pig or a relatively heavy weight pig. Intense fighting was displayed by the regrouped pigs immediately following mixing, while unmixed and Stresnil-treated pigs generally went to sleep.

During feeding periods, initiated aggression was the most common agonistic behaviour exceeding aggressive responses and submissive responses by a factor of up to 14. In mixed groups initiated aggression was significantly higher than in unmixed groups. Administration of Stresnil appeared to disrupt the animals' behavioural repetoire by delaying aggression, retarding social hierarchy establishment and depressing productivity. Prior occupancy of pen space also appeared to influence aggressive behaviour. Over the entire three week sample period, average daily weight gains (ADG) of all three mixed treatments were significantly less than unmixed groups. The differences were significant during the first week but not in the second or third weeks. The mixed groups were also

poorer converters of feed during the first week and over the three week period. Stresnil-treated pigs, on average, exhibited the poorest productivity of the mixed treatments. The economic costs of raising mixed groups from an initial weight of 76 kg to a standard final weight of 95 kg as a result of their reduced weight gain and feed efficiency, was substantial: $2.92 per pig for Stresnil-treated groups; $1.43 per pig for 3:3 mixed groups; and $1.13 per pig for 5:1 mixed groups. Assuming that growth rates remain the same, extrapolation of the data to a market weight of 102 kg resulted in overall costs of $3.50 per pig for Stresnil-treated groups, $1.94 per pig for 3:3 mixed groups and $1.54 per pig for 5:1 mixed groups.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

I would like to express my heartfelt thanks to Dr. David Shackleton, my supervisor, advisor, and on occasion, my assistant. His encouragement, support and advice over the years has meant a great deal to me. Many thanks to Dr. Richard Beames for allowing me to conduct my research at the University of British Columbia's swine unit, to my friend Mr. Thomas Riek, manager of the swine unit and to Mrs. Maureen Garland, coordinator of the Continuing Education department. Without their cooperation none of this would have been possible. I would also like to thank Drs. Richard Beames, Kimberley Cheng, and Ruth Newberry and Mr. Alfred Wahl, Swine Specialist, BCMAF for their constructive criticisms of this thesis. Many thanks to all the people who have supported my endeavours over the years; my family, friends and committee members, to name a few. Last but certainly not least, I would like to express my gratitude to my friend and assistant, Mr. Robert McCann. His hard work, worldly knowledge and quick wit made my research task easier and the work days shorter.

I would like to thank both Agriculture Canada and the British Columbia Ministry of Agriculture and Fisheries for providing funding for this project.

INTRODUCTION

Mixing unfamiliar pigs is common practice in many swine operations. Producers would like to maintain uniform pig weights within pens during the growing-finishing stages so that all the animals from a single pen can be marketed simultaneously, thereby optimizing efficiency, minimizing disease transmission, and reducing labour costs. Although the majority of producers try to regroup pigs in uniform weight groups during the early stages of growth, when stress is thought to be less (Jensen *et al.* 1969, cited in Jensen 1971; Hillyer 1972,1976), uniformity of weight at marketing is not often achieved. Currently, the premium paid for pigs of a standard slaughter weight is a monetary incentive that leads to the retention of underweight individuals until the desired market weight is achieved. It is not economical, however, to allow the few retained pigs to remain the sole occupants of a pen after their penmates have been marketed. Consequently, the producer is faced with either shipping underweight pigs at a reduced profit, or mixing them with other finishing pigs and hoping that they will not suffer setbacks in productivity.

Mixing unfamiliar pigs usually results in elevated levels of aggression. The majority of fighting occurs within the first half hour following mixing (Symoens and van den Brande 1969; Moss 1978), but can last anywhere from 1 h (Moss 1978) to 48 h (Ewbank and Meese 1971; Meese and Ewbank 1973). The greatest problem associated with regrouping is not only the increased aggression *per se*, but also its effect on productivity. Production problems range from a depression in animal performance (Teague and Grifo 1961) in the form of decreased weight gains, decreased feed efficiency, decreased feed intake, or a combination of these, to injuries and death in extreme cases (Symoens and Van den Brande 1969; Meese and Ewbank 1972; Kelley *et al.* 1980).

Although many aspects of post-mixing aggression have been studied in pigs weighing between 8 kg and 60 kg (Symoens and van den Brande 1969; Callear and van Gestel 1971; Ewbank and Meese 1971; Meese and Ewbank 1973; Sherritt *et al.* 1974; Graves *et al.* 1978; Dantzer and Mormede 1979; Arnone and Dantzer 1980; Kelley *et al.* 1980; Tindsley and Lean 1984), few researchers have examined effects on heavier pigs (Moss 1978; Hines 1985; McGlone *et al.* 1986). Moss (1978) studied aggression at the slaughterhouse, Hines (1985) examined mixing at different periods just prior to marketing, and McGlone *et al.* (1986) studied the use of pheromones as aggression modulators.

For the most part, studies of the relationship between aggression and animal performance show conflicting results. Some authors (Teague and Grifo 1961; Dantzer 1970, cited in Ewbank 1972; Graves *et al.* 1978) report depressions in performance when individuals are regrouped, while others (McGlone and Curtis 1981a; Friend *et al.* 1981) have found no significant reduction in productivity. Variations in the experimental conditions could account for many of these discrepancies, because mixing is probably only one factor which along with other stressors, such as group size, space reduction, and limited feeding, depresses animal performance (Sherritt *et al.* 1974; Graves *et al.* 1978).

The relationship between the growth stage of the animal and mixing has also been studied. Jensen and co-workers (1969, cited in Jensen 1971) felt that age may be a factor; mixing appearing to be less stressful for young pigs. Others recommend mixing a very large individual with a group of smaller pigs (Anonymous 1974; Stone 1983), assuming that the large individual is not likely to attack the smaller ones, nor be challenged by them. Tindsley and Lean (1984) showed, however, no significant treatment difference in aggression when pigs of unequal weights were mixed as compared with those of equal weights.

The concept of social status and its relationship with aggression has interested many researchers (Rasmussen *et al.* 1962; Ewbank 1969a,1972; Craig 1986; McGlone 1986b). Early researchers such as Rasmussen *et al.* (1962), described a stable, linear social order among swine; the general concept of which was in vogue at the time. More recent work by Ewbank (1969a) indicates that equal social status and circular relationships frequently occur, which seems typical in many other species (Richards 1974; Gauthreaux Jr. 1978). Although the concept of social status is not well understood and the determination of the social hierarchy is still plagued with problems (Richards 1974; Craig 1986; McGlone 1986b), high levels of mixing aggression are suggested to aid its establishment (Ewbank 1972). A reduction in aggression is said to follow the establishment of the social hierarchy (Beilharz and Cox 1967).

The relationship between social status and production traits is also unclear, if not contradictory. In some work, no relationships between social rank and body weight, nor between social rank and aggression have been found (Rasmussen *et al.* 1962; Ewbank and Meese 1971; Meese and Ewbank 1973; Fraser 1974), while other reports have shown strong correlations between rank and productivity (McBride *et al.* 1964; Beilharz and Cox 1967; James 1967; Ewbank 1972). Hansen (1977, cited in Hansen and Hagelso 1980) found that in pigs, growth was positively related to rank, provided the social hierarchy was stable.

As yet, no practical and effective solution to the problems associated with the mixing of pigs has been found. A wide variety of methods to reduce aggression have been investigated including odour masking compounds (Ewbank and Meese 1971; McGlone and Curtis 1981b; McGlone *et al.* 1981; Friend *et al.* 1981; McGlone *et al.* 1986; Meese and Baldwin 1975,1977); tranquilizers such as azaperone (Symoens and Van den Brande 1969; Callear and Van Gestel 1971) and other aggression-reducing chemical additives (Dantzer and Mormede, I979; Arnone and Dantzer 1980); physical barriers (McGlone and Curtis 1985; Fraser 1974); "toys" (Ashfield 1984); and mixing during darkness (Stone 1983). These have met with only limited success, and information on techniques for mixing finishing pigs is particularly lacking.

The objectives of this study were to:

1. determine if productivity was adversely affected by regrouping unfamiliar finishing pigs, and if so, to what extent,

2. examine the effects of group composition (sex, weight and different ratios of familiar and unfamiliar pigs) on regrouping, and

3. examine the effects of the commercial swine tranquilizer "Stresnil" (azaperone) on regrouping.

The purpose of this research was to provide useful behavioural guidelines for producers when mixing finishing pigs and to increase the level of knowledge about agonistic behaviour following mixing. Since pigs are not managed as individuals, the focus of this study was to examine group rather than individual behaviour.

METHODS

EXPERIMENTAL PROCEDURES

This research was conducted at the Specific Pathogen Free (S.P.F.) Swine Unit, Department of Animal Science, Faculty of Agricultural Sciences, University of. British Columbia. Crossbred Yorkshire x Landrace pigs of approximately 76 kg (initial weight) were used. They were housed in groups of six in pens of uniform size and construction, having concrete block walls and partially slatted, concrete floors (Figure 1). The pigs were limit-fed twice daily (maximium 3.1 kg per pig per day) with a commercial grower type ration of a nutrient concentration within the standard deviation boundaries set by the National Research Council for full fed pigs of 51 kg to 100 kg. Each pen was individually fed, the amount of feed recorded, and each pig was weighed (to the nearest 0.1 kg) every 3 to 4 days throughout a trial. The light regime was standardized automatically to 11 h light and 13 h dark, with a Tork Time Switch (Model 7100). The onset of the light cycle at 0730 hours was followed by the morning feeding at 0745 hours and the afternoon feeding at 1430 hours.

Shortly after birth, tails were docked, canine teeth were clipped, ears were notched, and males were castrated. Prior to mixing, each pig was individually marked on various parts of the body with either number applicators and black tattoo ink, or with felt pens. Due to the ease and speed of application very little stress was placed on the animals. Numbers remained legible for a period of 4 to 7 days and periodic checks were made by cross referencing the painted number with each pig's permanent

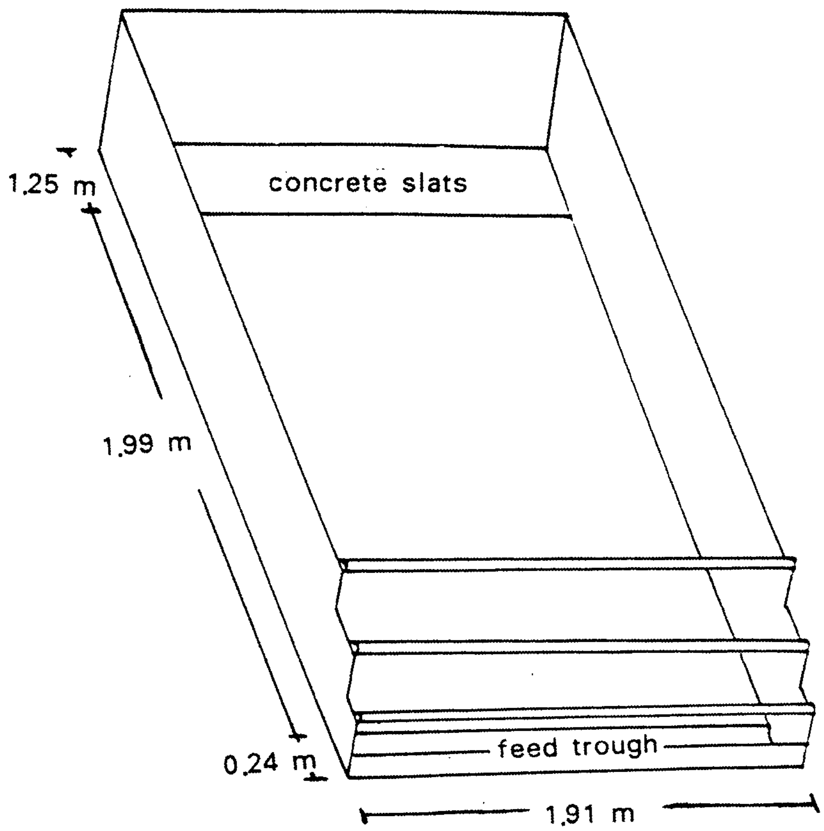

Figure 1. Grower pen design and dimensions.

ear notch number.

Treatments:

To determine the effects of mixing unfamiliar pigs on behaviour and productivity, the experiment consisted of 4 treatments (Table 1). Following weighing and marking, each group in Treatments 1 and 2 was held in the weighing room for approximately 5 min before being introduced into a clean, unfamiliar pen. In Treatment 3, each pig was injected subcutaneously with the manufacturer's recommended dose (1 ml per 18.2 kg liveweight) of 'Stresnil' (azaperone) prior to mixing (Pitman-Moore, MTC Pharmaceuticals). After a period of 15 to 20 min the pigs were simultaneously introduced into a new pen. In Treatment 4, two groups of 6 littermates each were weighed, marked, then returned to their respective pens. Five pigs from each litter were then moved to the holding area of the weighing room. After 5 min these groups of five were introduced into the pen containing either a single heavy unfamiliar occupant (on average 5.4 kg heavier than the heaviest pig of the introduced group) or a single light pig (on average 5.2 kg lighter than the lightest member of the introduced group. Due to the limited availability of empty pens, pigs in Treatment 4 could not be mixed into a new pen. Based on results attained by Meese & Ewbank (1973), Hansen *et al.* (1982), McGlone (1985) and results from Treatments 1 – 3, it was considered unnecessary to control the sex composition of the groups in Treatment 4.

Table 1. Experimental treatment combinations and replicates.

Treatment no.	Replicates	Treatment Combination
1 (unmixed)	3	- 6 male littermates - 6 female littermates - 3 male / 3 female littermates
2 (3:3 mixed)	3	- 3 male: 3 male mixed group - 3 female: 3 female mixed group - 3 male: 3 female mixed group
3 (3:3 mixed) (with) (Stresnil)	3	- 3 male: 3 male mixed group treated with Stresnil - 3 female: 3 female mixed group treated with Stresnil - 3 male: 3 female mixed group treated with Stresnil
4 (5:1 mixed)	4	- 5 mixed with 1 relatively heavy pig - 5 mixed with 1 relatively light pig

Observations:

Agonistic interactions within unmixed and within mixed treatments were observed and quantified A) in the first 2 h immediately following moving/mixing and B) during feeding periods.

A. Agonistic Behaviour Immediately Following Mixing

When groups were first mixed, a continuous 2 h video film was made to accurately record the frequent, rapid agonistic interactions. The identities of the interactors and the occurrences and the duration of the following agonistic interactions were then measured by reviewing the videotape:

i. Fights - a continuous aggressive interaction involving two or more individuals. A fight was terminated when the interactors moved more than 1 m apart and both were facing away from each other for at least 10 s or when the interactors were spatially separated by one or more other pigs.

ii. Pursuit/Retreat - a sequence involving aggression by at least one individual and retreat by at least one other interactor.

Due to equipment problems video recordings of 9 of the unmixed groups, 4 of the 3:3 mixed groups, and 2 of the 5:1 mixed groups were unobtainable.

B. Agonistic Behaviour During Feeding

Limit-feeding created a competitive situation among the pigs. Commencing the first morning after mixing, all occurrences of agonistic behaviour displayed by the group was conducted (focal group sampling)

(Altmann 1974) for the first 30 min after feed was introduced, four times a week (Treatments 1 - 3) and twice a week (Treatment 4), for 3 weeks. Data collection was confined to morning feeding sessions to increase internal validity. The following data were collected by direct observation, recorded with a Sony TC-110B tape recorder and subsequently transcribed onto computer sheets: the identities of the initiator and the recipient of any agonistic behaviour pattern (a retaliation was scored for any aggressive behaviour that occurred within 2 s of the previous aggressive action); the type of agonistic behaviour pattern; the time at which the agonistic interaction occurred; and the outcome of any competition for resources (successful or unsucessful).

Due to the difficulty of assessing the precise onset and termination of an interaction, behaviour patterns rather than interactions were scored. The following agonistic behaviour patterns were recorded:

Aggressive Patterns

Bites - opening and closing the mouth near, or on, part of another's body (Kelley *et al.* 1980); each individual bite was recorded.

Tuskings - a sideways, upwards sweeping blow with the snout against the head or the body of the receiver. Equivalent to head knocks (Jensen 1984).

Threats - vocalizations, postures, facial or body movements that either signal aggression (McGlone 1986b) or produce a submissive response in an interactor. Non-contact aggressive patterns could be distinguished from threats by the completion of the aggressive action in the former and not in the latter.

Submissive Patterns

Retreats - movement away from an interactor.

Displacements - a lateral shift away, or a departure from, the feed trough in response to aggression from an interactor.

Submissive posture - a stance, displayed in response to aggression from an interactor, in which the back is arched, and the tail and ears are lowered (Meese & Ewbank 1973).

These specific agonistic patterns were grouped into three functional behavioural categories:

Aggressive Initiations - the sum of initiated bites, tuskings and threats.

Aggressive Responses - the sum of retaliatory bites, tuskings and threats.

Submissive Responses - the sum of retreats, displacements, and submissive postures.

In spite of the virtues of using broad categories in describing feeding behaviour, biting behaviour, alone, can be of some value. Biting behaviour can serve as a good indicator of changes in aggression over time because 1) it commonly occurs among unfamiliar animals, and is usually absent among acquainted animals (Fraser 1974); 2) it correlates well with both total aggression and dominance outcomes (McGlone 1986b); 3) it has low variability; and 4) it is easily recognized and therefore repeatable among observers (Kelley *et al.* 1980). Bites are also "complete" aggressive patterns, and as such are less ambiguous than threats.

Analysis of variance (ANOVA) was used, but when not appropriate (eg. due to departures from normality or homoscedasticity), nonparametric tests were applied. A probability level of $\alpha=0.05$ was selected *a priori* for hypothesis testing and $\alpha=0.10$ for Scheffe's range test because of its conservative nature (Winer 1962).

ASSESSING SOCIAL STATUS

Submissive behaviours and outcomes of competition for food and water were used to assess relative social status. Intrusions (aggressive and non-aggressive attempts to obtain resources) were scored and recorded as either successful or unsuccessful depending on the outcome. Displacements, retreats, successful and unsuccessful intrusions, and submissive postures, were used to construct a sociometric matrix of "winners" and "losers" (Altmann 1974). Under the controlled conditions of this study, every animal had an equal probability of being observed and therefore the requirements of the sociometric matrix outlined by Altmann (1974) were met. A winner was considered to be a pig that elicited a submissive response from another pig, or one which successfully intruded between one or more pigs. The outcome of intrusion attempts were, for the most part, unambiguous; resulting in a clear winner and loser(s). The one exception was the case in which a pig was unsuccessful in its intrusion attempt between two feeding pigs. In this case it could not be determined if the intruding pig was unsuccessful because of the presence of only one, the other, or both of the feeding pigs.

Only encounters with unambiguous outcomes were used to calculate the relative social status of each pig within the group. "Dominance Values" (DV's), using the arcsine square root transformed average proportion of wins of each pig (0.0 to 1.0) (Beilharz and Cox 1967) were then calculated from the sociometric matrix. These DV's were ranked within groups to estimate relative social status. Landau's Index of Linearity (h) was calculated from the DV's, and if $h \geq 0.9$, the social hierarchy was assumed to be linear (Lehner 1979).

RESULTS

AGONISTIC BEHAVIOUR IMMEDIATELY FOLLOWING MIXING

Fighting almost always occurred within a few minutes after pigs were introduced to their new pen. Overall, 3:3 mixed pigs displayed the highest rate and duration of agonistic interactions (fighting and pursuit/retreat) per group per minute of observation time (0.441/min; 24.8s/min; n=5) followed by the 5:1 mixed groups (0.822/min; 9.3s/min; n=7), and the Stresnil-treated groups (0.15/min; 1.9s/min; n=9) with the unmixed littermates showing the lowest levels (0.002/min; 0.016s/min; n=7).

AGONISTIC BEHAVIOUR DURING FEEDING

No significant differences were found in any of the agonistic categories between the different sex combinations examined (Aggressive initiations, H=0.1,df=2; Aggressive responses, H=5.2,df=2; Submissive responses, H=1.3,df=2; Bites, H=.5,df=2). Agonistic behaviour differed markedly among the treatments and was quite variable over the 3 weeks following mixing (Table 2). Aggressive initiations were, by far, the most common behaviour patterns; the probability of a response behaviour reaching a high of 0.81 in unmixed groups and ranging from a low of 0.07 to a high of 0.35 in mixed groups (Table 3). Aggressive initiations did not differ significantly among the treatments in the first morning following mixing (Kruskal-Wallis:H=3.3,df=3), but by the end of the first week, significant differences were apparent occurred (H=13.7,df=3) and continued throughout the second and third weeks (H=9.0,df=3, H=8.4,df=3

Table 2. Behaviours of unmixed, 3:3 mixed, Stresnil-treated and 5:1 mixed groups.

Behaviour	unmixed groups (n=9)	3:3 mixed groups (n=9)	Stresnil-treated groups (n=9)	5:1 mixed groups (n=8)
	Mean number of behaviours per group per 30 min sample during feeding			
Aggressive initiations				
Day 1[a]	45.2	65.6	74.9	89.5
Week 1	39.9^{b}	78.0^{c}	89.9^{c}	77.8^{b}
Week 2	46.1^{b}	72.9^{c}	76.1^{c}	$61.6^{b,c}$
Week 3	44.9^{b}	$69.3^{b,c}$	70.4^{c}	$69.6^{b,c}$
Overall	43.6^{b}	73.4^{c}	78.8^{c}	$69.7^{b,c}$
Aggressive responses				
Day 1[a]	26.3^{b}	8.6^{c}	$15.6^{b,c}$	$13.4^{b,c}$
Week 1	20.5	12.5	16.1	16.3
Week 2	15.4	17.6	13.5	14.7
Week 3	13.6	19.7	12.3	14.1
Overall	16.5	16.6	14.0	15.0
Submissive responses				
Day 1[a]	9.8	23.1	17.3	8.5
Week 1	8.6^{b}	26.1^{c}	$13.8^{b,c}$	8.5^{b}
Week 2	$9.7^{b,c}$	25.6^{b}	7.0^{c}	5.3^{c}
Week 3	$8.3^{b,c}$	24.1^{b}	$7.7^{b,c}$	6.9^{c}
Overall	$8.8^{b,c}$	25.2^{c}	$9.5^{b,c}$	6.9^{b}
Aggressive responses/Aggressive initiations				
Day 1[a]	$.56^{b}$	$.14^{c}$	$.24^{d}$	$.18^{c}$
Week 1	$.64^{b}$	$.17^{c}$	$.19^{c}$	$.23^{c}$
Week 2	$.38^{b}$	$.26^{b,c}$	$.19^{c}$	$.33^{b,c}$
Week 3	$.31^{b,c}$	$.33^{b}$	$.19^{c}$	$.29^{b,c}$
Overall	$.44^{b}$	$.25^{c}$	$.19^{c}$	$.28^{b,c}$
Submissive responses/Aggressive initiations				
Day 1[a]	.22	.32	.23	.14
Week 1	$.22^{b}$	$.30^{b}$	$.18^{b,c}$	$.13^{c}$
Week 2	$.19^{b}$	$.31^{b}$	$.09^{c}$	$.09^{c}$
Week 3	$.17^{b,c}$	$.30^{b}$	$.11^{c,d}$	$.11^{d}$
Overall	$.19^{b}$	$.30^{b}$	$.13^{c}$	$.11^{c}$
Bites				
Day 1[a]	8.7^{b}	37.6^{c}	32.4^{c}	$34.6^{b,c}$
Week 1	7.6^{b}	38.3^{c}	35.5^{c}	$27.0^{b,c}$
Week 2	9.4^{b}	23.6^{c}	21.7^{c}	8.8^{b}
Week 3	6.9^{b}	25.1^{c}	15.9^{c}	$14.3^{b,c}$
Overall	7.9^{b}	29.0^{c}	24.4^{c}	$16.7^{b,c}$

** [a] First morning after day of mixing

[b,c,d] Means with different superscripts, within each row are significantly different ($P < 0.05$)

Table 3. Ratios of response behaviours to initiated behaviours of unmixed, 3:3 mixed, Stresnil-treated and 5:1 mixed groups.

AGGRESSIVE RESPONSES : AGGRESSIVE INITIATIONS

Sample[a]	Unmixed groups	3:3 mixed groups	Stresnil-treated groups	5:1 mixed groups
1	0.56	0.14	0.24	0.18
2	0.77	0.18	0.14	----
3	0.81	0.12	0.23	0.28
4	0.44	0.24	0.18	----
5	0.38	0.18	0.18	0.28
6	0.38	0.28	0.18	----
7	0.34	0.24	0.29	0.37
8	0.41	0.32	0.20	----
9	0.24	0.34	0.20	0.24
10	0.41	0.29	0.15	----
11	0.29	0.34	0.21	0.33
12	0.31	0.35	0.22	----

** [a] Four samples in each week

SUBMISSIVE RESPONSES : AGGRESSIVE INITIATIONS

Sample[a]	Unmixed groups	3:3 mixed groups	Stresnil-treated groups	5:1 mixed groups
1	0.22	0.32	0.23	0.14
2	0.23	0.28	0.16	----
3	0.24	0.28	0.18	0.12
4	0.20	0.33	0.17	----
5	0.16	0.30	0.10	0.09
6	0.22	0.31	0.10	----
7	0.21	0.34	0.07	0.08
8	0.18	0.30	0.11	----
9	0.17	0.29	0.13	0.11
10	0.15	0.27	0.09	----
11	0.19	0.31	0.11	0.10
12	0.17	0.32	0.10	----

** [a] Four samples in each week

respectively) (Table 2). Over the entire 3 week period, the differences in aggressive initiations were significant (H=11.0,df=3).

Pigs in unmixed groups exhibited fewer aggressive initiations than those in the other treatments throughout the 3 week period (Table 2). With the exception of the first day following mixing, pigs treated with Stresnil showed the highest average weekly and overall, levels of initiated aggression (Table 2), but there was a noticeable decline in the aggression they and the other mixed treatments initiated over time (Figure 2). In spite of this decline by the third week, the aggression initiated in the mixed treatments was still higher than that in unmixed groups.

The mean number of aggressive responses did not change after the second or third day post-mixing (Figure 3). No significant differences between the treatment groups were found other than those observed on the first day (H=9.4,df=3; Table 2). On the first day following mixing the unmixed groups displayed significantly more aggressive responses per aggressive initiations than the 3:3 mixed group (Mann-Whitney:U=8.5). The 3:3 mixed group exhibited the fewest aggressive responses on the first day and to the end of the first week (Table 2). The ratios of aggressive responses to aggressive initiations showed similar trends to those of the mean number of aggressive responses in all the treatment groups except for the 5:1 mixed treatment. The ratio of aggressive responses to aggressive initiations of 5:1 mixed treatment showed an increase through the first and second weeks (Table 2).

The treatment groups differed significantly in their levels of submissive behaviour over the 3 week period (H=8.3,df=3; Table 2).

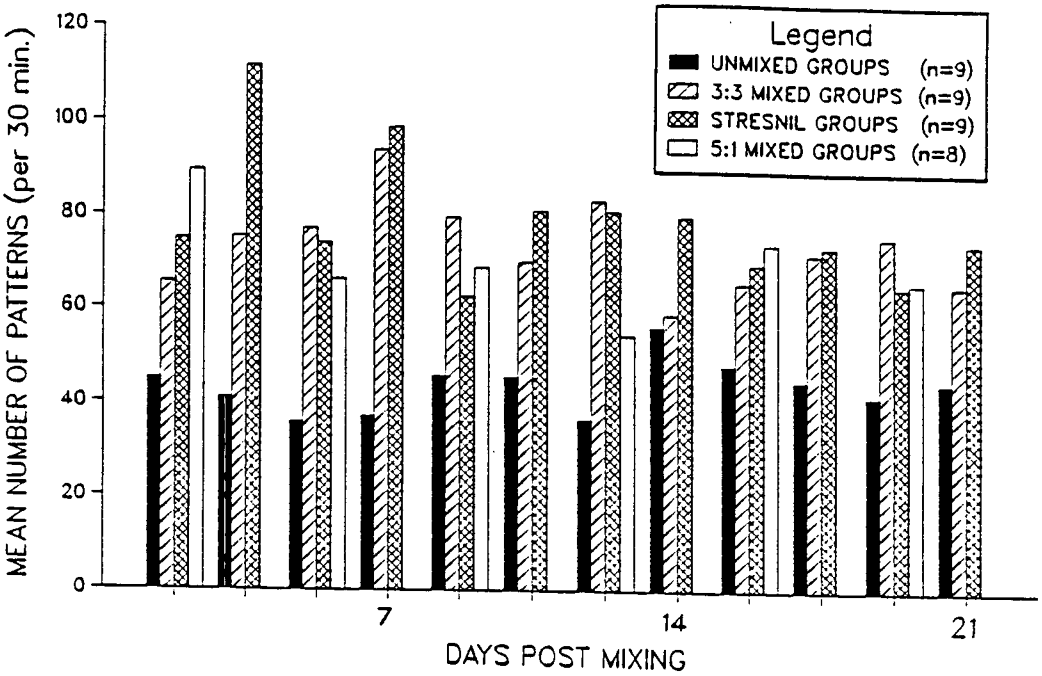

Figure 2. Initiated aggression of unmixed, 3:3 mixed, Stresnil-treated, and 5:1 mixed pigs.

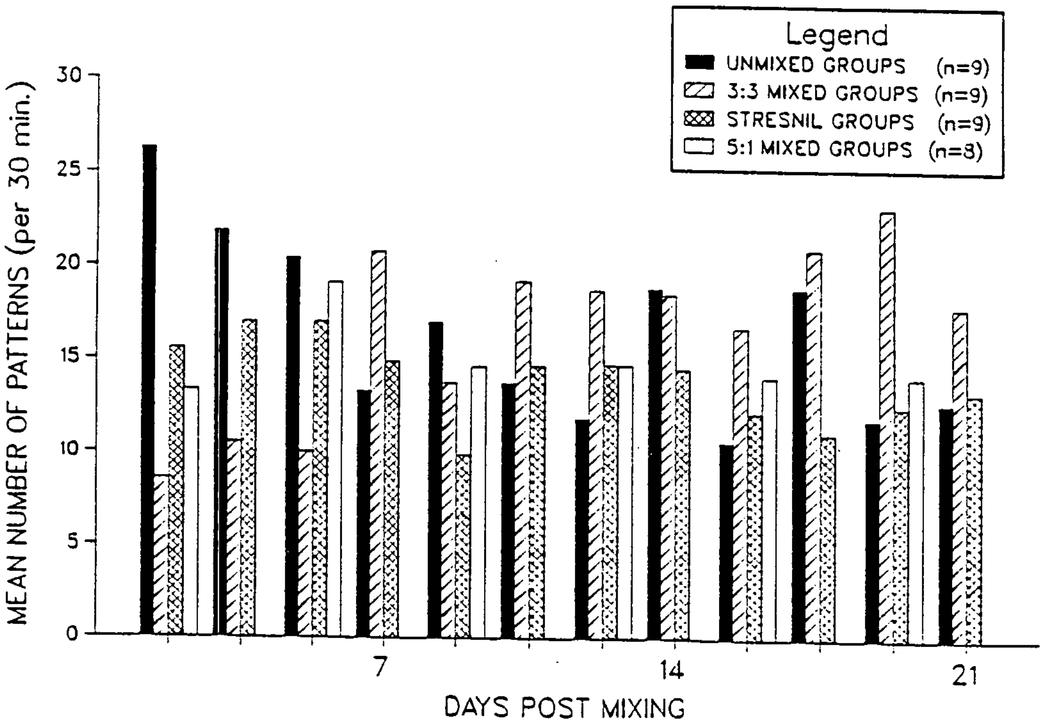

Figure 3. Aggressive responses of unmixed, 3:3 mixed, Stresnil-treated, and 5:1 mixed pigs.

Although there were no significant differences observed on the first day following mixing ($H=4.5, df=3$), by the end of the first week differences were significant ($H=8.2, df=3$), and remained so throughout the second ($H=10.7, df=3$) and third weeks ($H=7.7, df=3$). With the exception of the Stresnil-treated groups, the ratios of submissive responses to initiated aggression remained fairly constant throughout the 3 week period (Table 2).

The 3:3 mixed group displayed the highest incidence of submissive behaviours (Figure 4), and by the end of the third week, their level still had not declined to those of the other groups. The 5:1 mixed groups exhibited the lowest level of submissive behaviour, although they were not statistically different from those for pigs in the unmixed groups.

Biting behaviour differed significantly between treatment groups in every time period tested (Table 2). In the first day, significant differences were evident between the unmixed and 3:3 mixed groups ($U=10.0$), and between the unmixed and Stresnil-treated groups ($U=13.5$). These differences persisted throughout the 3 weeks. The levels of biting in the 5:1 mixed groups were intermediate. Pigs in the 3:3 mixed groups displayed the highest incidence of biting behaviour, but a distinct peak in the mean number of bites was observed in the Stresnil-treated groups on the second day (Figure 5).

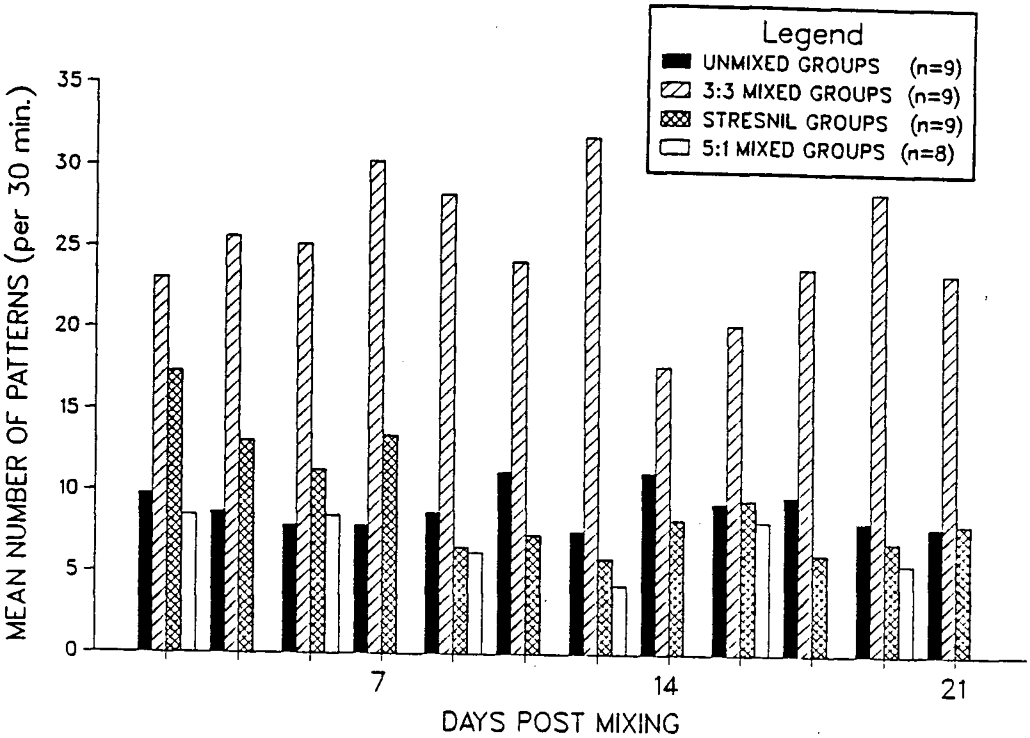

Figure 4. Submissive responses of unmixed, 3:3 mixed, Stresnil-treated, and 5:1 mixed pigs.

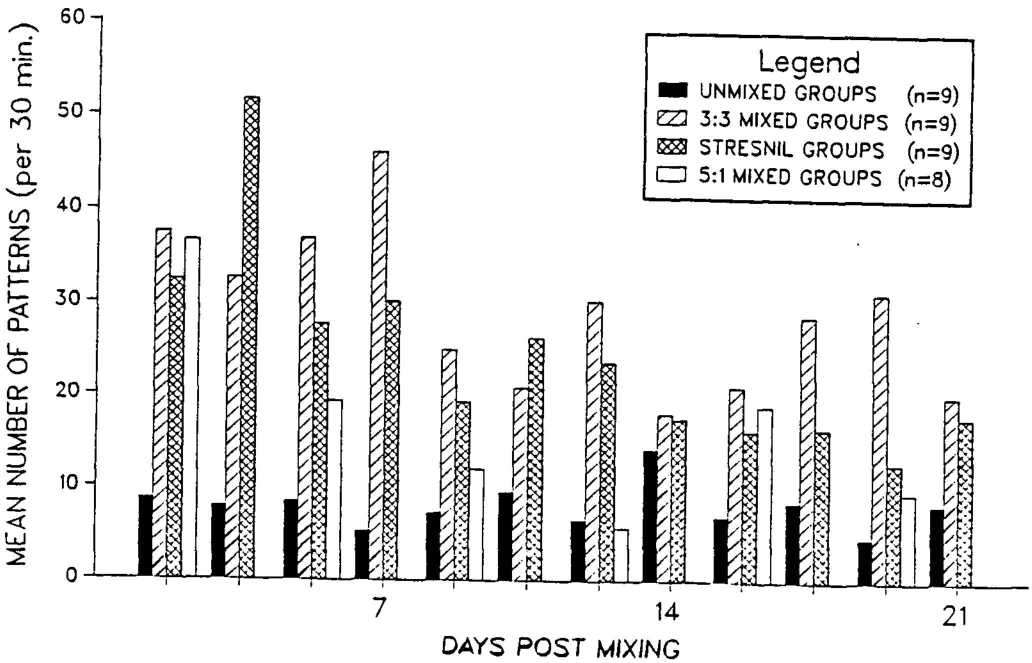

Figure 5. Bites of unmixed, 3:3 mixed, Stresnil-treated, and 5:1 mixed pigs.

EFFECTS OF MIXING ON SOCIAL HIERARCHIES

A. Structure of hierarchies

The social hierarchies of the unmixed and mixed groups were quite different with respect to structure. In 78% (n=9) of the unmixed groups the hierarchy was non-linear, while in the 3:3 mixed and Stresnil treatments, only 22% (n=9) and 56% (n=9) of the groups exhibited non-linearity, respectively.

In the 5:1 mixed groups, non-linear social hierarchies were found in 88% of the pens (n=8). A complete hierarchy could not be constructed for one group because some animals did not interact with each other during the observation periods. The relative social status of the single original occupant was not consistent; the single individuals occupied either an intermediate position (no. 2 no. 5) in the hierarchy (75%; n= 6), or were the most subordinate (25%).

B. Social Status and Weight Gain

Feeding pigs were often observed using their their bodies to block access to food by non-feeding individuals (Figure 6). The non-feeding individuals were commonly animals of low social status, but in spite of the differential ability of pigs to obtain food, only the 3:3 mixed groups showed a significant correlation between weight gain and relative social status, and only during the first week (Kendall:γ=-.25,df=52). The magnitude of the differences in weight gain was such that over 3 weeks the correlation was still significant (γ=-.21,df=52).

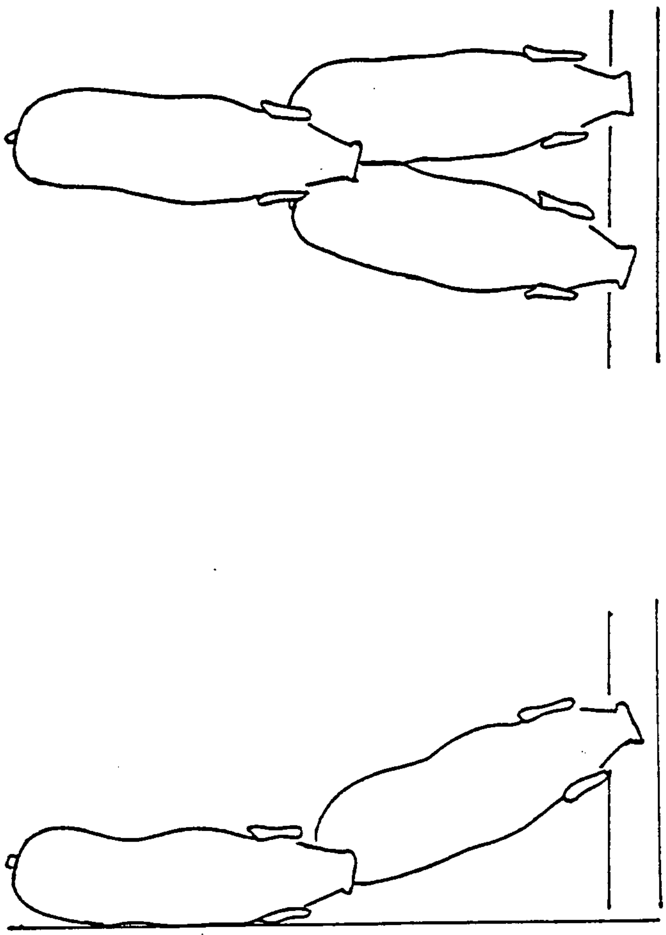

Figure 6. Orientation of feeding pigs' bodies to block access to feeder.

EFFECTS OF MIXING ON WEIGHT GAIN

Consistently, unmixed groups had a higher average daily weight gain (ADG) than any other treatment groups. Over the 3 week sample period differences in ADG among the treatment groups were significant ($F=3.73, df=3$) because of the large differences during the first 3 days ($F=5.56, df=3$) and throughout the first week ($F=3.30, df=3$). By the second and third weeks, these differences were no longer significant ($F=1.57, df=3$ and $F=0.92, df=3$). Neither the initial starting weights (i.e. using the initial starting weight as a covariate; $F=1.12, df=1$), nor the sex combinations used ($F=0.82, df=2$), had significant effects on ADG.

Over the three week period there was a noticeable change in the pattern of ADG among treatments. Although the ADG of 3:3 mixed groups were initially much lower than that of unmixed groups, by the second week they had reached a level comparable to that of the unmixed groups (Figure 7). The other treatments were intermediate to the unmixed and 3:3 mixed groups and showed similar trends. Averaged over the entire 3 weeks, the greatest differences occurred betweeen unmixed pigs and Stresnil-treated and 5:1 mixed groups, indicating that while the 3:3 mixed group had progressively better ADG over time, the Stresnil-treated and 5:1 mixed groups did not grow as well (Table 4).

In the 5:1 mixed group treatment, no significant difference in weight gain was found between light weight and heavy weight original occupants in any of the weeks tested (first week, $F=0.01, df=1$; second week, $F=0.03, df=1$; third week, $F=0.16, df=1$) nor over the 3 weeks ($F=0.05, df=1$). When the ADG's of the single heavy pigs were compared to the ADG's of

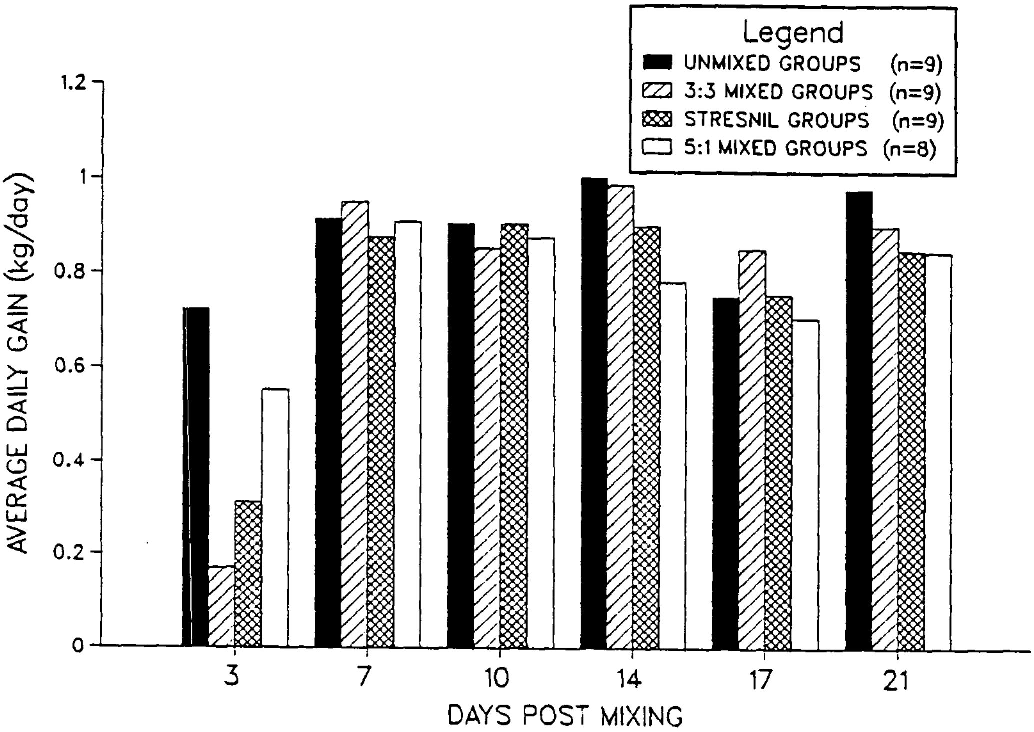

Figure 7. Average daily gain (ADG) of unmixed, 3:3 mixed, Stresnil-treated, and 5:1 mixed pigs.

Table 4. Average daily gain (ADG) of unmixed, 3:3 mixed, Stresnil-treated, and 5:1 mixed pigs.

	$\bar{x}$ (± S.E.) Average Daily Weight Gain ($kgday^{-1}$)			
Time period	unmixed groups (n=9)	3:3 mixed groups (n=9)	Stresnil-treated groups (n=9)	5:1 mixed groups (n=8)
First 3 days	0.72 ± 0.37^{a}	0.17 ± 0.35^{b}	$0.31 \pm 0.21^{a,b}$	$0.55 \pm 0.29^{a,b}$
Week 1	0.83 ± 0.14^{a}	0.62 ± 0.17^{b}	$0.63 \pm 0.18^{a,b}$	$0.76 \pm 0.20^{a,b}$
Week 2	0.96 ± 0.14	0.93 ± 0.11	0.90 ± 0.14	0.82 ± 0.15
Week 3	0.88 ± 0.18	0.88 ± 0.13	0.81 ± 0.14	0.78 ± 0.13
Overall	0.89 ± 0.07^{a}	$0.81 \pm 0.08^{a,b}$	0.78 ± 0.08^{b}	0.79 ± 0.09^{b}

** a,b Means with different superscripts, within each row are significantly different ($P < 0.05$)

the other individuals in the group, no significant difference was found (first week, F=2.53,df=1; second week, F=0.53,df=1; third week, F=0.39,df=1; over the 3 weeks, F=0.30,df=1). Similarly, the ADG's of the original light weight pigs were not significantly different from those of the other group members (first week, F=3.75,df=1; second week, F=1.41,df=1; third week, F=0.01,df=1; over the 3 weeks, F=2.24,df=1)

EFFECTS OF MIXING ON FEED EFFICIENCY

Trends similar to those of ADG's were found among the feed per gain ratios (F/G) of treatment groups. Significant differences were apparent in the first week, but not in the second or third weeks (F=3.83,df=3; F=1.45,df=3 and F=0.41,df=3, respectively), although averaged over the 3 week sample period, the F/G's were significant (F=4.22,df=3). Sex had no significant effect on F/G (F=3.12,df=2) over the entire 3 weeks.

Throughout the experiment, pigs in unmixed groups were generally the most efficient in converting food to weight gain, and Stresnil-treated pigs were the most inefficient converters (Table 5). Within 5:1 mixed groups no significant difference in the F/G was found between groups with single unfamiliar heavy individuals and those with single unfamiliar light weight pigs (F=0.26,df=1).

Table 5. Feed per Gain Ratios (F/G) of unmixed, 3:3 mixed, Stresnil-treated, and 5:1 mixed pigs.

$\bar{x}$ (± S.E.) Feed per Gain(kg kg^{-1})				
Time period	unmixed groups (n=9)	3:3 mixed groups (n=9)	Stresnil-treated groups (n=9)	5:1 mixed groups (n=8)
Week 1	3.47 ± 0.51^{a}	4.63 ± $1.09^{a,b}$	4.74 ± 1.36^{b}	3.72 ± $0.70^{a,b}$
Week 2	3.15 ± 0.43	3.25 ± 0.38	3.39 ± 0.52	3.64 ± 0.68
Week 3	3.69 ± 0.95	3.69 ± 0.65	4.03 ± 0.74	3.90 ± 0.79
Overall	3.35 ± 0.28^{a}	3.74 ± 0.36^{b}	3.85 ± 0.31^{b}	3.65 ± $0.28^{a,b}$

** [a,b] Means with different superscripts, within each row are significantly different ($P < 0.05$)

ECONOMIC IMPLICATIONS OF MIXING

Based on linear regressions of weight gain (Table 6), the estimated days to a common final weight of 95 kg from an initial liveweight of 76 kg were calculated as follows: unmixed treatment, 21.08 days; 3:3 mixed, 22.92 days; Stresnil-treated, 23.63 days; and 5:1 mixed, 23.68 days (Figure 8). Extrapolating further to a market weight of 102 kg, the estimated additional days to market were 7.62 days for the unmixed treatment, 7.66 days for the 3:3 mixed, 8.14 days for Stresnil-treated, and 8.59 days for 5:1 mixed pigs (Figure 8). Based on these projections and 1987 estimates of feed costs, pen space, and drug cost, the added costs associated with mixing were $1.43/pig (to 95 kg), $1.94/pig (to 102 kg) for the 3:3 mixed; $2.92/pig (to 95 kg), $3.50/pig (to 102 kg) for Stresnil treated; and $1.13/pig (to 95 kg), $1.54/pig (to 102 kg) for 5:1 mixed (see Appendix 1 for calculations). Since feed cost was the largest variable cost it had a much greater influence on total cost than days to a common final weight.

Table 6. Linear regressions of weight (W:kg) over time (t:days).

Treatment	Regression equation
Unmixed groups	$W = 0.91823\ t + 75.645$
3:3 mixed groups	$W = 0.91414\ t + 74.050$
Stresnil-treated groups	$W = 0.86018\ t + 74.674$
5:1 mixed groups	$W = 0.81500\ t + 75.698$

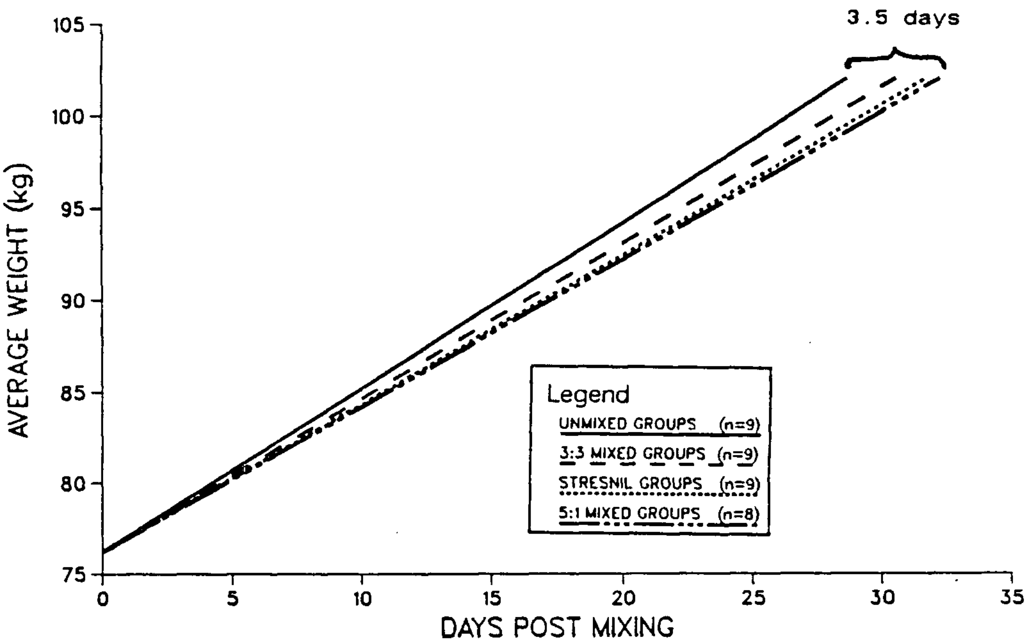

Figure 8. Estimated days to market based on linear regressions of weight gains (Regression lines have been adjusted to common initial and final weights).

DISCUSSION

Mixing pigs is a management procedure that has not been well studied, yet has profound effects on behaviour and productivity. Although behaviour and productivity may appear to be unrelated, they are, in fact, closely linked; changes in behaviour often being reflected by depressions in productivity. An understanding of the effects of mixing on behaviour is therefore essential to optimizing productivity.

EFFECTS OF MIXING ON BEHAVIOUR

Most authors recognize two different phases of aggression when pigs are mixed: 1) immediate post-mixing aggression, and 2) aggression displayed in competition for limiting resources such as food (Fraser 1974; Arnone 1979, cited in Arnone and Dantzer 1980; Dantzer and Mormede 1979; Arnone and Dantzer 1980). Initially, the lack of familiarity between the animals (Fraser 1974) and the disruption of previous social hierarchies influence aggression, but after familiarity has been achieved, limited access to the resource is the dominant factor. These two phases of aggression are by no means independent, the outcomes of immediate post-mixing agonistic interactions probably greatly influencing an individual's ability to obtain food resources later.

Agonistic Behaviour Immediately Following Mixing

When unfamiliar animals were grouped together, a significant increase in aggression occurred. In contrast to the agonistic interactions during feeding which rarely involved more than one aggressive pattern, interactions during the initial mixing period resembled those described for wild pigs (Fradrich 1974; Jensen and Wood-Gush 1984; Barrette, 1986); prolonged with many patterns performed. It has been suggested that the increase in aggression is necessary for the formation of the new social hierachy (Symoens and van den Brande 1969; Ewbank and Meese 1971; Meese and Ewbank 1973; McGlone 1986a). While durations of fighting have been reported to range from 8 h (Symoens and van den Brande 1969) to 48 h (Ewbank and Meese 1971; Meese and Ewbank 1973; McGlone 1986a), most of the intensive fighting in this study ceased within 24 h. Only occasionally was fighting observed in the morning following mixing.

Not surprisingly the greatest amount of immediate post-mixing aggression was observed in the 3:3 mixed groups, probably because the largest number of unfamiliar animals were present in this treatment. Within each 3:3 group, there was a total of nine possible dyadic interactions between unfamiliar animals. This is in contrast to the 5:1 mixed treatment which displayed the second highest level of immediate post-mixing aggression and where there were only five possible dyadic interactions between unfamiliar animals. Among the unmixed groups, no fighting occurred and although single aggressive behaviour patterns were exchanged, they were uncommon. After a period of intense investigatory activity of their new pen, the unmixed animals generally lay down and slept. There are two obvious conclusions from these findings. First, unfamiliarity between group members promotes agonistic interactions and second, greater numbers of unfamiliar animals result in increased fighting.

Animals sedated with the tranquilizer Stresnil exhibited the least amount of aggression of all the mixed groups during the immediate post-mixing period, most likely because of the properties of the drug (retarding coordination and inducing sleep). In the Stresnil-treated groups however, sporadic fighting was observed during the first and second morning's feeding periods whereas fighting had ceased in most of the other treatment groups by these times. Reports of Stresnil-treated animals fighting following their recovery from the sedative effects of the drug (often as much as undrugged animals) have also been made by other researchers (Marsboom 1969; Symoens and van den Brande 1969). Given the fast acting nature of the drug, the sedated pigs would be expected to display even less aggression than the fully conscious unmixed groups, but there were probably two reasons why this did not occur. First, Stresnil appeared to affect pigs differentially, producing deep sedation in some pigs while only drowsiness in others. Second, the sedated animals had to be awakened in order to move them into the new pen.

The original pen occupant in the 5:1 mixed treatment displayed very interesting behaviour. Although obviously outnumbered by unfamiliar group members, the original occupant initiated the first bouts of aggression in every trial. Wild pigs are not known to be territorial (Matschke and Hardister 1966; Kurz and Marchinton 1972; Wood and Brenneman 1980; Singer *et al.* 1981; Tisdell 1982), but the behaviour of the original pen occupant would seem to suggest that under confined conditions, prior ownership of space may influence aggression, or individual distance may increase under stress. Conversely, aggressive tendencies of the introduced pigs could have been inhibited by a combination of the stress of moving to a new pen, and being faced with an occupant. This inhibition of aggressive tendencies is unlikely, however, because in other mixed treatments new surroundings and new group mates were associated with an increase in agonistic interactions. Although priority of ownership may encourage original pen occupants to display more aggression than they otherwise might, the single pigs were not always successful in their agonistic encounters with introduced group members.

Agonistic Behaviour During Feeding

Agonistic behaviour at the feeder was probably the most important aspect of this study because of its direct relationship to productivity. The measurement of this type of behaviour is not without its difficulties, however. In the past, many researchers have failed to adequately define their terminology when describing behaviours (Fraser and Rushen 1987). Also, the absence of a standardized set of behaviour patterns makes comparison between studies difficult and finally, many individual behaviour patterns have extreme variances. The data from this study and that of Meese and Ewbank (1972) indicates that levels of individual behaviours often change drastically from day to day. In light of these problems, the use of broad functional categories is often more useful in describing feeding aggression than discrete units of behaviour. For this study, the behavioural categories, aggressive initiations, aggressive responses, and submissive responses were chosen and are, in fact, synonymous with the three physiological mechanisms of behaviour recognized by Adams (1979) as offensive attack, defensive attack, and submission.

The influence of the moving process on established groups of pigs has not been closely examined in feeding aggression studies, although it is not generally considered to be stressful. My data and those of Mardarowicz (1985), indicate that moving alone does stress the animals. This stress was reflected in the behaviour of the unmixed pigs following their introduction into a new pen. In the first week, the unmixed pigs exhibited more aggressive responses than in subsequent weeks. This was most noticeable in the first day, and in fact, the unmixed groups exhibited the highest level of aggressive responses of any treatment during this period. Interestingly enough, the process of moving did not increase an animal's tendency to initiate aggression nor to bite. Rather, it appeared to reduce an animal's tolerance of, or lack of overt reaction to, any initiated aggression. Submissive behaviour, in contrast, did not fluctuate greatly over time, which may not be surprising if, as has been suggested, the social hierarchy is maintained primarily through the behaviour of the subordinates (Collias 1944; Rowell 1966; Jensen and Wood-Gush 1982; McCort and Graves 1982; Jensen 1982,1984). Presumably, the social hierarchy of unmixed groups had been established prior to the animals being moved into the new pen.

In contrast to the unmixed groups, the process of mixing unfamiliar pigs resulted in several behavioural changes during feeding. Biting behaviour probably best illustrates the extreme stress associated with mixing. As observed in immediate post-mixing aggression, biting behaviour appeared to be related to the number of unfamiliar animals in the treatment. The average number of bites was highest in the 3:3 mixed treatment followed by the Stresnil-treated and 5:1 mixed treatments. Although it declined steadily, by the end of 3 weeks the numbers of bites in all the mixed groups were still more than twice that of unmixed groups. While this suggests that aggression does decrease over time as familiarization occurs, the process is slow.

The presence of stress in the mixed treatments was also evident from the elevated levels of initiated aggression. The mean number of aggressive initiations far exceeded the levels of either aggressive responses or submissive responses; as much as 14 times in some mixed groups. In unmixed groups there was a higher frequency of retaliations and zero responses.

The exceptionally low levels of initiated aggressive behaviour in the 3:3 mixed groups, and to a lesser extent, the Stresnil-treated groups in the first morning following regrouping were interesting and somewhat unexpected. Although a continuation of the high levels of aggression displayed in the previous day would have been expected, the apparent lull in aggression can be explained *a posteriori*. There were likely two factors depressing aggression in the first morning following mixing; fatigue, and newly acquired social status. Many of the pigs appeared to be exhausted from the effects of immediate post-mixing fighting as only a few pigs were present at the trough during the feeding period. In addition, some of the pigs that attempted to gain access to the feeder were aggressively repulsed, and after a few attempts lay down again, leaving only a few pigs at the feeder.

In the 5:1 mixed treatment no decrease in initiated aggression was observed in the first morning following regrouping. As there was only one unfamiliar member in the 5:1 treatment and few intra-litter agonistic encounters occurred, fatigue was not a major factor in this case, at least among the five littermates. The combination of moving stress, more pigs at the feeder, and the intense aggression by the single original occupant, also probably contributed to the high levels of aggression at this time.

Since Stresnil is usually voided from the system within 24 h (Marsboom 1969; Porter and Slusser 1984), the behaviour of the drugged animals should have been similar to that of the 3:3 mixed groups following the post-mixing period, but this was not the case. Stresnil-treated groups displayed the highest level of initiated aggressive behaviour in every time period tested. There was also an extremely high peak of initiated aggression during the second morning following mixing. During the first and second mornings following mixing agonistic interactions at the feeder often escalated into severe fighting in the middle of the pen. The competition at the feeder therefore served as the catalyst or stimulus for more intense and prolonged agonistic interactions; interactions that were more typically seen immediately following mixing. These findings indicate that rather than eliminating fighting as claimed by the manufacturer, MTC Pharmaceuticals, Stresnil delays the onset of aggression and may therefore retard the establishment of the social hierarchy.

The submissive responses of the Stresnil treatment also differed from that of the 3:3 mixed treatment, again indicating that the drug probably has prolonged effects on the pigs' behavioural repetoire. After the first week, Stresnil treated groups displayed a dramatic decline in submissive responses that cannot be readily explained. The initial high levels of submissive behaviour during the first week can probably be attributed to a combination of high levels of aggressive initiations and low levels of aggressive responses. With aggressive initiations and aggressive responses only declining slowly, however, no reason can be found for the sudden decrease in submissive behaviour.

The patterns of initiated aggression and submissive responses in the 5:1 mixed treatment showed two peaks; the second smaller than the first but nevertheless, distinct. This is probably due to two factors: mixing animals and introducing animals into a pen that is already occupied. Initially the single animal probably exhibited aggression due to its familiarity with the surroundings. The introduced group also exhibited aggression, first because of the stress associated with moving, and second because of the presence and behaviour of an unfamiliar individual. Following the defeat of the single individual by the members of the littermate group, agonistic behaviour declined. As familiarization among the animals occurred, however, agonistic behaviour increased once more as the single individual sought to establish its position within the hierarchy. The extremely low levels of submissive responses, even in comparison to the unmixed treatment, indicates that because the single pig has the advantage of being familiar with the surroundings and the group has the advantage of numbers, neither are likely to act submissively.

Perhaps the most interesting trend displayed was that of aggressive responses. During the first day after mixing, pigs in 3:3 mixed groups were the least likely to respond aggressively, probably because of the newness of the social hierarchy and the fierce competition for the highest social ranks. Not only were retaliations by low ranking members of the group met with overt aggression (e.g. bites), but also subordinate animals were relentlessly pursued. As familiarization occurred and pursuit of low ranking members declined, aggressive responses increased. This increase is interesting, because in combination with the decrease in initiated aggression, it could indicate a general increase in the social tolerance probably approaching that found in unmixed groups. Increases in social tolerance would most probably occur only with increasing familiarity among group members and stability in social orders (Collias 1953).

The trend of aggressive responses in the Stresnil treatment after the post mixing period is somewhat puzzling. As opposed to the increase seen in the 3:3 mixed treatment, a gradual decline in aggressive responses was observed in the Stresnil-treated pigs over the 3 weeks. Relative to initiated aggression, aggressive responses did not change over the 3 weeks. The lack of an increase in the trend of aggressive responses may have occurred for a number of reasons, all related to Stresnil having differential effects on the pigs. The first is that the drug may have excited some (aggressive) individuals while sedating others (less aggressive animals). If this were the case, then the aggressive animals would be advantaged from the outset; their elevated aggression reinforcing the learning process and inhibiting the aggressive responses of the less aggressive pigs. The second possiblility is that the drug had its greatest effect on the less aggressive animals. Dominant animals are believed to be more aggressive than subordinate ones (Ewbank and Meese 1971; Hansen *et al.* 1982), and this attribute could have raised the dominants' tolerance of the drug to a point where the drug's effective threshold was not reached. Consequently, the full or partial behavioural repertoire of the aggressive animals would remain intact while the subordinates would be unable to respond aggressively. The third possibility is that the drug had a differential effect on the type of aggression displayed. Offensive aggression (initiations) and defensive aggression (responses) are thought to be controlled by different neural mechanisms (Brown 1970), so if the tranquilizer acted preferentially on one pathway, a disruption of the complete behavioural repertoire could result. Drugs such as lithium carbonate are known to decrease intra-group aggression among feeding pigs while being ineffective in preventing aggression in newly regrouped pigs (Dantzer and Mormede 1979). Similarly, amphetamines have been shown to affect dominant squirrel monkeys differently from subordinate monkeys (Miczek and Gold, 1983; Miczek *et al.* 1984) and other drugs have differential effects on the behaviour of aggressive and timid mice (Krsiak *et al.* 1984). Clearly further research is necessary to determine the full effects of Stresnil on pig behaviour.

The trend of aggressive responses in 5:1 mixed groups was also different from either the 3:3 mixed and Stresnil-treated groups. Rather than following the bimodal distributions of aggressive initiations and submissive responses, aggressive responses in 5:1 mixed groups slowly declined. While at first this might suggest increasing familiarity, this does not necessarily have to be the case. Although aggressive responses declined absolutely over the three weeks, relative to aggressive initiations they increased slightly during the second week. A similar trend was observed in the 3:3 mixed groups during the same time period, but in the third week aggressive responses in the 3:3 mixed group continued to increase while they decreased in the 5:1 mixed groups. Initially a single pig is likely to initiate aggression as a means of defending its familiar space at the feeder. However, it is unlikely to continue this behaviour for a prolonged period of time when confronted by five unfamiliar animals.

Influence of Sex on Behaviour

In all the treatments in this study, no differences were found in agonistic behaviour between the sexes. While similar observations have been made by some (Meese and Ewbank 1973; Hansen *et al.* 1982; McGlone 1985b), others have suggested that barrows are more aggressive (McBride *et al.* 1964; Beilharz and Cox 1967; Gallwey and Tarrant 1978, cited in Stephens 1980). The lack of sex differences was not unexpected since the average starting age of the pigs in this experiment was about 136 days and the onset of puberty in females is normally between 180 - 210 days and in intact males is about 120 - 150 days (Whittemore 1980; Pond and Maner 1984). Further, the use of castrated, rather than intact males reduced any effects of male hormones on aggression.

SOCIAL STRUCTURE AND STATUS

An understanding of social structure and organization in swine is important to both the researcher and the producer. In this study the assessment of individual social status was based on two measures; general submissive behaviours and competitive outcomes over access to feed and water. Van Kreveld (1970) has defined dominance as "a priority of access to an approach situation or to leaving an avoidance situation" and although there is much debate on the virtues of the different methods of assessment (Richards 1974; Craig 1986; McGlone 1986b), dominance in pigs has generally been evaluated in two ways. The first method involves scoring the frequency and direction of aggressive interactions within groups (e.g. Rasmussen *et al.* 1962; Ewbank and Bryant 1972; Meese and Ewbank 1972, 1973; Fraser 1974) and the second examines outcomes of competition for resources (e.g. Scheel *et al.* 1977; Craig 1986).

Most of the aggression is thought to be displayed by dominant individuals (Ewbank and Meese 1971; Hansen *et al.* 1982), but it was felt that the direction of aggression was not always a good indicator of dominance. In this study and those of McBride *et al.* (1964) and Ewbank and Bryant (1972), some feeding subordinates were observed to initiate aggressive behaviour when higher ranking individuals intruded at the feed trough. Under these circumstances, often little or no aggression was displayed by the intruding dominant individuals. Further, low ranking pigs were observed, at times, to retaliate when displaced from the feeder. For these reasons the exhibition of submissive behaviour, rather than aggressive behaviour was used in this study to determine social status. Rather than using a single competitive measure such as replacements (displacements) at the feeder (Meese and Ewbank 1973), both displacements and intrusion attempts were recorded to gain a better picture of the social relationships.

Social Structure

The social hierarchy structure varied between the treatments, as different structures seemed to reflect the differing degrees of familiarity among the animals in each treatment. In the 3:3 mixed groups, strongly linear hierarchies predominated, presumably the result of the high levels of unfamiliarity among the animals. In this treatment overt aggressive interactions quickly established a clearly defined hierarchy with no undisputed social positions. In the Stresnil treatment, which should have had the same levels of unfamiliarity among members, some groups exhibited linear hierarchies while others displayed non-linear hierarchies. The drug may therefore not only delay the onset of aggression but also seems to interfere with the normal development of a hierarchy.

Wilson (1975) has suggested that for most animals the formation of a linear hierarchy implies the stabilization of the dominance order. While this may be true of newly formed social hierarchies, the data from this study indicate that this is not necessarily true in established hierarchies. Non linear hierarchies were common in groups containing familiar groupmates (unmixed and 5:1 mixed groups), complete with reversals and triangular relationships. There are a number of possible reasons for this. First, the social hierachies of established groups may be maintained through covert rather than overt agonistic patterns. Consequently, the current methods of assessment may be unable to measure subtle behaviours used to maintain the hierarchies. Second, familiar individuals may be more tolerant of violations to their social positions by other group members; and third, our measurement or understanding of the role and functioning of hierarchies may be inaccurate. Certainly there is much discussion on the way we measure and interpret such social structures (Richards 1974; Craig 1986; McGlone 1986b).

Social Rank and Weight Gain

Dominance is said to confer advantages to high ranking individuals when resources are either limited or localized (Craig 1986). Usually individuals of high social status obtain most of a resource (McBride *et al.* 1964; Ewbank 1969a; Craig 1986), or the majority share almost equal amounts while the most subordinate receives little or none (Craig 1986). In this study some pigs were observed to be actively excluded from the feed trough by the orientation of the feeding pigs' bodies. This behaviour was most obvious in the first week but also continued in subsequent weeks. As a result, the differential ability of high ranking individuals to acquire food was reflected in the weight gains of the 3:3 mixed groups during the first week and over the 3 weeks. While this relationship was not apparent in the Stresnil-treated groups, it is probably due to their delayed aggression and unsettled social structure.

Other researchers have found that when animals are limit fed, growth rate is related to social rank and fighting (Bryant and Ewbank 1972; Dantzer 1972a,b, cited in Sherritt *et al.* 1974). McBride and co workers (1964) estimated that 13% of the total variance in growth is due to social rank, and other studies have shown that dominant pigs spend more time at the feed trough (Baxter 1983/84; Hansen *et al.* 1982). Although Rasmussen *et al.* (1962) found no correlation between social status and weight gain, they recognized that the degree of competition for food was not high in their experiments.

EFFECTS OF MIXING ON PRODUCTIVITY

Many of the stress related changes in behaviour patterns were clearly associated with the pigs' weight gains and feed conversions. While some researchers have been unable to find an effect of regrouping animals on weight gains (Teague and Grifo 1961; Jensen 1971; Dantzer 1970, cited in Ewbank 1972; Graves *et al.* 1978) and others suggest a temporary improvement in feed efficiency (Friend *et al.* 1981), mixing significantly depressed both the growth and feed efficiency of pigs in treatments involving mixed pigs in this study. Although differences in average daily gain were observed only in the first week, similar to reports by McGlone *et al.* (1986) for 55 - 58 kg pigs, there was a carryover effect of the initial differences in this study. No significant differences in weight gain occurred during either the second or third weeks, but over the entire 3 week period significant differences were apparent. Similarly, mixing resulted in poor conversion of feed, with the 3:3 mixed and Stresnil treatments being the most inefficient. Teague and Grifo (1961), have also observed that mixing during the growing-finishing period decreases feed efficiency. These results suggest that though animals may appear to eat well after regrouping, stress is still present, and affects productivity. The combined findings of weight gain and feed conversion are obviously of considerable importance to the producer because they demonstrate that mixing has covert but long term depressive effects on productivity.

Moving to a new pen was also associated with a decline in the productivity of the animals. This was readily apparent from the depressed weight gain of the unmixed animals during the first week as compared to subsequent weeks. Mixed groups are therefore not only exposed to stress asssociated with mixing, but also to stress caused by being moved to new surroundings.

Although the 3:3 mixed groups showed the lowest average daily gain in the first week, by the third week they were gaining proportionally more than the other mixed groups. The intense fighting displayed immediately after regrouping may have established the new social hierarchy faster than in the other mixed treatments, and as a result, fewer disputes and hence less stress, occurred in the last two weeks. Tindsley and Lean (1984) have also suggested that a shorter period of hierarchy establishment may be beneficial. In their experiment, even-weight groups showed more aggressive retaliations than dissimilar weight groups, but established a hierarchy and gained weight faster.

Using animal production parameters as indicators of well-being, Stresnil-treated groups appear to be affected by stress factors for a longer period than untreated 3:3 mixed groups. Initial tests of Stresnil in Europe did not measure animal production (Callear and van Gestel 1971; Symoens and van den Brande 1969) while later ones have claimed that Stresnil increases average weight gain (Ludvigsen 1970, cited in Callear and van Gestel; Symoens and Gaert, unpublished, cited in Callear and van Gestel; Crown Chemical Co. Ltd., Lamberhurst, Kent, cited in Blackshaw 1981; Porter and Slusser 1984), and feed efficiency (Porter and Slusser 1984). In this study and that of Blackshaw (1981), however, Stresnil was not effective in improving relative growth rate.

The weight gains observed in the 5:1 mixed group were rather unique. Initially, groups in this treatment showed good average gains compared to the other mixed groups, as expected, because only one unfamiliar member was present in this treatment and so should have contributed little to average values. Over the 3 weeks, however, these groups did not show the same improvement observed in the 3:3 mixed groups. As in the Stresnil-treated groups, this indicates long term stress. This stress appeared to affect the whole group, rather than just the single individual or the introduced animals since no difference was observed in the weight gains of the single heavy or light pigs, and those in the rest of group.

As observed with agonistic behaviour, the sex of the pigs had no effect on weight gains. The productivity of both sexes appeared to be affected equally by the mixing conditions imposed on them.

CONCLUSIONS

It is obvious from this study that mixing pigs from different groups or litters adversely affects finishing swine. Not only does mixing promote aggression and fighting but it also significantly affects productivity, and hence, economic returns, both in the short and long term. Even after three weeks, the initial setback in productivity was still apparent and in this study the additional costs of mixing were substantial ($1.94/pig for 3:3 mixed, $3.50/pig for Stresnil treated, and $1.54/pig for 5:1 mixed). Rather than eliminate fighting, the tranquilizer Stresnil appeared to disrupt the animals' behavioural repertoire, delaying the peak aggressive period, thus retarding the establishment of a "stable" social hierarchy, and further depressing productivity. The introduction of animals into occupied pens also appears to disrupt the normal process of hierarchy formation; priority of ownership of space having a significant influence on aggressive behaviour. Maintaining pigs in the same groups, when moved to a new pen, appeared to cause some disruptions of the social hierarchy and productivity. However these disruptions were only short-lived and consequently detrimental effects on production were minimized.

RECOMMENDATIONS

Regrouping pigs is commonly practised on many swine operations, but it cannot be recommended from my research. Regrouping adversely affects productivity and also has a negative impact on the welfare of the animals. The stress associated with regrouping has also been found to predispose pigs to illness, injuries and according to some researchers, even death (Meese and Ewbank 1972). At least one researcher has commented that fighting to the point of death seems to have increased in recent years (Stone 1983). In my study, one pig suffered a broken leg due to fighting and another contracted an illness that necessitated its removal from the group for a period of time. A few animals also suffered temporary illnesses or developed abscesses as a result of injuries sustained in fighting. Barring death, injury or illness, the losses in productivity from mixing pigs should be sufficient to discourage producers from this practice. Although setbacks in weight gain and feed efficiency are usually only reported in the first week, my results show that they last as long as 3 weeks.

In any production system, the costs of mixing would naturally have to be weighed against those of any increased housing costs for smaller groups. Thus far, however, it appears that the economic effects of mixing pigs has never been calculated in the literature. For the swine operator the economic costs of mixing is a major consideration in making management decisions and in my study, the additional housing and feed costs to retain mixed pigs from an initial weight of 76 kg to a final weight of 95 kg were substantial: $1.43/pig for 3:3 mixed groups, $2.92/pig for

Stresnil-treated groups, and $1.13 for 5:1 mixed groups (1987 Canadian dollars). Extrapolating to a market weight of 102 kg, the additional costs associated with mixing were even greater (see Appendix 1 for cost analysis). My calculations do not include the extra costs associated with providing pens to separately house animals that contract illnesses or are injured as a result of mixing, medical treatment, nor the labour that is needed during the extra days that mixed pigs spend in the pens.

In situations where regrouping pigs is unavoidable, however, a number of recommendations can be followed:

1. Feed pigs *ad libitum* during the first week following mixing

The virtues of *ad libitum* feeding versus restricted feeding and its influence on mixed pigs is contradictory. Sherritt *et al.* (1974) and Graves *et al.* (1978) found that mixed litters that were initially limit-fed grew more slowly than other groups, while pigs which were mixed but not limit-fed, initially grew at rates comparable to those of unmixed groups. Other studies have shown significant differences in productivity among mixed and unmixed treatments even with *ad libitum* feeding systems (Hines 1985; McGlone and Curtis 1985; McGlone *et al.* 1986), however, and at least one European producer has had relatively good weight gains in mixed pigs with restricted feeding 4 times a day (Best 1971). In spite of these conflicting results, swine operations practising limit feeding may benefit by feeding newly regrouped pigs *ad libitum* during the first week. During the first week, when aggression is at its highest and subordinates are often prevented from feeding, imposing nutritional stress can only increase animals' susceptibility to illnesses. Although feed efficiency may still suffer with the implementation of an *ad libitum* feeding system, newly mixed animals are not likely to lose as much condition as they would under a limit feeding system; also, the limit-feeding system can always be re implemented after the first week.

2. Ensure that there is sufficient feed trough space in the pen

Feeder space is especially important with mixed pigs because of the high level of aggression that is displayed at the feeder. In established groups less agonistic activity is shown but a certain baseline level is usually maintained and that level tends to increase if the area decreases (Craig 1986). Space is, therefore, a prized possession and feeder space that would normally be sufficient for established groups probably will be insufficient for mixed groups. This is particularly true in the first week following mixing. In these experiments, subordinate animals were often prevented from feeding due to the close proximity of aggressive individuals. Even with an *ad libitum* feeding system, Hansen and Hagelso (1980) experienced problems with pigs guarding the feeders. Partitioned feed troughs or multiple feeding areas may therefore aid in decreasing aggression.

3. Move animals into a new pen

It is apparent that priority of possession or use of space plays a role in aggression when animals are introduced into an occupied pen. In these experiments, fierce aggression was displayed by original pen occupants. Under certain circumstance, this behaviour may be used to advantage by the manager. For example, it would probably be more beneficial to mix a large group into the pen of a small group.

4. Avoid use of the tranquilizer "Stresnil"

The use of Stresnil and related tranquilizers as management aids have received much publicity in recent years. In spite of the claims to the contrary, Stresnil is not cost effective when used in conjunction with regrouping. Initial tests of Stresnil in Europe (Callear and van Gestel 1971; Symoens and van den Brande 1969) showed that the drug was successful both in preventing aggression when pigs were mixed and stopping fighting once it had started. However, the drug does not eliminate fighting entirely but merely delays it. In addition, no improvement in weight gain or feed efficency is obtained with Stresnil. Stresnil may play a better role in other aspects of swine management such as reducing sow aggression towards piglets and reducing the incidence of stress-related diarrhoea in piglets during weaning (Symoens 1975).

5. Placing large animals into a group of finishing pigs serves no purpose

Introducing large individuals into a group of small pigs has been recommended by a few individuals (Anonymous 1974; Houpt and Wolski 1982; Stone 1983). Within the weight range of finishing pigs, no improvement is achieved by mixing a large individual with a group of finishing pigs, although if a finishing pig were mixed with a group of weaners or growers the results might be different.

FUTURE RESEARCH NEEDS

The common practice of mixing finishing pigs still deserves further investigation. Based on these results, mixing has long term effects on the productivity of the animals, causing depressions in performance that are detectable even after 3 weeks post-mixing. Much of the current research is aimed at reducing aggression in the short term (e.g. pheromones, tranquilizers, odour masking compounds, etc.), but as results with Stresnil show, reductions in visible aggression may not necessarily be a valid indicator of reduced stress.

In order to optimize productivity, pig producers would probably benefit from first, trying to establish the new social hierarchy in the shortest time possible (e.g. by initial contact through adjacent pen fences etc.) and second, providing a means for individuals of all social ranks to obtain food and escape from aggression. In this regard, protected individual feeding and escape areas may help reduce the stress of mixing for pigs of low social status. Currently, some work is being carried out along these lines. Hide boxes (McGlone and Curtis 1985), pens utilizing a maze system (Nehring 1981) and two level pig pens (Philips and Fraser 1987) are being examined. Research should also be directed at developing systems where the mixing of unfamiliar pigs is unnecessary. Multiple group farrowing with a common area for the piglets would allow pigs to become accustomed to each other at an early age.

One concept that definitely deserves future consideration is that of kin recognition among finishing pigs and the existence of an "interlitter" social order. Preliminary data from my study suggests that interlitter social organization exists and may have a greater influence on mixing than do other factors such as sex and initial starting weight. In this study few intralitter fights were observed following mixing and on ocassion, two pigs from one litter were observed fighting with one pig from another litter. In addition, the pigs from one litter were often found to occupy the top ranks of the social hierarchy. The full implications of this new concept will not be known without further research.

LITERATURE CITED

Adams, D.B. 1979. Brain mechanisms for offense, defense and submission. Behav. Brain Sci. 2:201

Altmann, J. 1974. Observational study of behaviour: sampling methods. Behav. 49:227-267.

Anonymous. 1974. Social behaviour of the pig. Vet. Rec. 95:123.

Arnone, M. and Dantzer, R. 1980b. Does frustration induce aggression in pigs? Appl. Anim. Ethol. 6:351-362. Appl. Anim. Ethol. 11:74-75 (abstract).

Ashfield, G. 1984. Pigs at play are less aggressive, more productive. Feedstuffs 56(10):1.

Barrette, C. 1986. Fighting behaviour of wild *Sus scrofa*. J. Mamm. 67(1):177-179

Baxter, M.R. 1983/84. Feeding and aggression in pigs. Appl. Anim. Ethol. 11:74-75 (abstract).

Beilharz, R.G. and Cox, D.F. 1967. Social dominance in swine. Anim. Behav. 15:117-122.

Best, P. 1971. Making light of mixing. Pig Farming 19(5):30-33.

Blackshaw, J.K. 1981. The effect of pen design and the tranquilising drug, Azaperone, on the growth and behaviour of weaned pigs. Austr. Vet. J. 57:272-276.

Brown, J.L. 1970. The neural control of aggression. In Animal Aggression: Selected Readings. Southwick, C.H. (ed). Van Nostrand Reinhold Co. New York. pp. 164-186

Bryant, M.J. and Ewbank, R. 1972. Some effects of stocking rate and group size upon agonistic behaviour in groups of growing pigs. Br. Vet. J. 128:64-69.

Callear, J.F.F. and van Gestel, J.F.E. 1971. An analysis of the results of field experiments in pigs in the U.K. and Ireland with the sedative neuroleptic Azaperone. Vet. Rec. 89:453-458.

Collias, N.E. 1944. Aggressive behaviour among vertebrate animals. Physiol. Zoo. 17(1):83-123

Collias, N.E. 1953. Social behaviour in animals. Ecology 34:810-811.

Craig, J.V. 1986. Measuring social behaviour: Social dominance. J. Anim. Sci. 62:1120-1129

Dantzer, R. and Mormede, P. 1979. Effects of lithium on aggressive behaviour in domestic pigs. J. Vet. Pharmacol. Therap. 2:200-303.

Ewbank, R. 1969a. Social behaviour and intensive animal production. Vet. Rec. 85:183-186.

Ewbank, R. 1972. Social environment of the pig. In: D.J.A. Cole (ed.), Pig Production. Pennsylvania State University Press, University Park, PA, pp. 129-139.

Ewbank, R. and Bryant, M.J. 1972. Aggressive behaviour amongst groups of domesticated pigs kept at various stocking rates. Anim. Behav. 20:21-28.

Ewbank, R. and Meese, G.B. 1971. Aggressive behaviour in groups of domesticated pigs on removal and return of individuals. Anim. Prod. 13:685-693.

Fradrich, H. 1974. A comparison of the behaviour of the *Suidae*. pp. 133-143, In: The Behaviour of Ungulates and its Relation to Management (eds. V. Geist and F. Walther), IUCN New Series, no. 24

Fraser, D. 1974. The behaviour of growing pigs during experimental social encounters. J. Agric. Sci., Camb. 82:147-163.

Fraser, D. and Rushen, J. 1987. A plea for precision in describing observational methods. Appl. Anim. Behav. Sci. 18:205-209.

Friend, T.H., Tanksley, T.D. and Krabe, D.A. 1981. Behaviour and performance of pigs grouped by three different methods at weaning. J. Anim. Sci. 53 (suppl. 1):127 (abstract).

Gauthreaux, Jr., S.A. 1978. The ecological significance of behavioural dominance. In: Bateson & Klopfer (eds) Perspectives in Ethology. Vol. 3: Chapt. 2. Plenum Press, New York.

Graves, H.B., Graves, K.L. and Sherritt, G.W. 1978. Social behaviour and growth of pigs following mixing during the growing-finishing period. Appl. Anim. Ethol. 4:169-180.

Hansen, L.L. and Hagelso, A.M. 1980. A general survey of environmental influence on the social hierarchy function in pigs. Acta Agric. Scandinavica 30:388-391.

Hansen, L.L., Hagelso, A.M. and Madsen, A. 1982. Behavioural results and performance of bacon pigs fed "ad libitum" from one or several self-feeders. Appl. Anim. Ethol. 8:307-333.

Hillyer, M. 1972. Mixing litters. Pig Farming 20(5):103

Hines, R.H. 1985. Effect of mixing on performance of finishing swine. Agric. Expt. Stn., Kansas Stat. Univ. Prog. Rep. 486:94-97

Houpt, K.A. and Wolski, T.R. 1982. Domestic Animal Behaviour for Veterinarians and Animal Scientists. Iowa State Univ. Press. Iowa. p. 45.

James, J. W. 1967. The value of social status to cattle and pigs. Proc. Ecol. Soc. Aust. 2:171-181.

Jensen, A.H. 1971. Biological implications of intensive swine rearing systems. J. Anim. Sci. 32:560-565.

Jensen, P. 1982. An analysis of agonistic interaction patterns in group-housed dry sows - aggression regulation through an "avoidance order". Appl. Anim. Ethol. 9:47-61.

Jensen, P. 1984. Effects of confinement on social interaction patterns in dry sows. Appl. Anim. Behav. Sci. 12:93-101.

Jensen, P. and Wood-Gush, D.G.M. 1984. Social interactions in a group of free-ranging sows. Appl. Anim. Behav. Sci. 12:327-337.

Kelley, K.W., McGlone, J.J. and Gaskins, C.T. 1980. Porcine aggression: Measurememt and effects of crowding and fasting. J. Anim. Sci. 50:336-341.

Krsiak, M., Sulcova, A., Donat, P., Tomasikova, Z., Dlohozkova, E., Kosar, E. and Masek, K. 1984. Can social and agonistic interactions be used to detect anxiolytic activity of drugs? Ethopharmac. Aggression Res. Alan R. Liss, New York, NY pp. 93-114

Kurz, J.C. & Marchinton, R.L. 1972. Radiotelemetry studies of feral hogs in South Carolina. J. Wildl. manage. 36:1240-1248.

Lehner, P.N. 1979. Handbook of Ethological Methods. Garland Press. New York.

McBride, G., James, J.W. and Hodgens, N. 1964. Social behaviour of domestic animals. IV. Growing pigs. Anim. Prod. 6:129-139.

McCort W.D. and Graves, H.B. 1982. Social dominance relationships and spacing behaviour of swine. Behav. Processes 7:169-178.

McGlone, J.J. 1985. A quantitative ethogram of aggressive and submissisve behaviours in recently regrouped pigs. J. Anim. Sci. 61:559-565.

McGlone, J.J. 1986a. Influence of resources on pig aggression and dominance. Behav. Processes 12:135.

McGlone, J.J. 1986b. Agonistic behaviour in food animals: Review of research and techniques. J. Anim. Sci. 62:1130-1139.

McGlone, J.J. and Curtis, S.E. 1981a. A behaviour/performance study to evaluate an alternative nursery pen design for swine. J. Anim. Sci. 53 (Suppl. 1):129-130 (abstract)

McGlone, J.J. and Curtis, S.E. 1981b. Effect of gender on aggression-influencing properties in swine urine. J. Anim. Sci. 53 (Suppl. 1):130 (abstract).

McGlone, J.J. and Curtis, S.E. 1985. Behaviour and performance of weanling pigs in pens equipped with hide areas. J. Anim. Sci. 60:20-24.

McGlone, J.J., Curtis, S.E. and Banks, E.M. 1981. Aggression-influencing pheromones in swine. J. Anim. Sci. 53 (Suppl. 1):130 (abstract)

McGlone, J.J., Stansbury, W.F. and Tribble, L.F. 1986. Aerosolized 5*-androst-16-en-3-one reduced agonistic behaviour and temporarily improved performance of growing pigs. J. Anim. Sci. 63:679-684.

Mardarowicz, L. 1987. Mardarowisc, I. Pig News and Information 8(1): (abstract)

Marsboom, R. 1969. On the pharmacology of Azaperone, a neuroleptic used for the restraint of wild animals. Acta Zool. Path. Ant. 48:155-161.

Matschke, G.H. & Hardister, J.P. 1966. Movements of transplanted European wild boar in North Carolina and Tennessee. Proc. Ann. Conf. S.E. Assn. Game & Fish Comm. 20:74-84.

Marsboom, R. 1969. On the pharmacology of Azaperone, a neuroleptic used for the restraint of wild animals. Acta zool. path. Antwerp. 48:155-161.

Meese, G.B. and Baldwin, B.A. 1975. The effects of ablation of the olfactory bulbs on aggressive behaviour in pigs. Appl. Anim. Ethol. 1: 251-262.

Meese, G.B. and Baldwin, B.A. 1977. Sensory factors in the social behaviour of pigs. Appl. Anim. Ethol. 3:203 (abstract).

Meese, G.B. and Ewbank, R. 1972. A note on instability of the dominance hierarchy and variations in levels of aggression within groups of fattening pigs. Anim. Prod. 14:359-362.

Meese, G.B. and Ewbank, R. 1973. The establishment and nature of the dominance hierarchy in the domesticated pig. Anim. Behav. 21:326–334.

Miczek, K.A. and Gold, L.H. 1983. d–Amphetamine in squirrel monkeys of different social status: Effect on social and agonistic behaviour, locomotion and stereotypies. Psychopharm. 81:183–190.

Miczek, K.A., DeBold, J.F. and Thompson, M.L. 1984. Pharmacological, hormonal, and behavioural manipulations in the analysis of aggressive behaviour. pp. 1–26 In: Ethopharmacological Aggression Research. Alan R. Liss, Inc. New York.

Moss, B.W. 1978. Some observations on the activity and aggressive behaviour of pigs when penned prior to slaughter. Appl. Anim. Ethol. 4:323–339.

Nehring, A. 1981. One answer to the confinement pig problem. Int. J. Stud. Anim. Prob. 2(5):256–259.

Philips, P.A. and Fraser, D. 1987. Design, cost and performance of a free–access, two–level pen for growing finishing pigs. Can. Agric. Eng. 29(2):193–195.

Pond, W.G. and Maner, J.H. 1984. Swine Production and Nutrition. AVI Publ. Co. Conneticut. pp. 124–138.

Porter, D.B. and Slusser, C.A. 1984. Reducing stress in swine. Anim. Nutr. Health Nov./Dec.:14–23.

Rasmussen, O.G., Banks, E.M., Berry, T.H. and Becker, D.E. 1962. Social dominance in gilts. J. Anim. Sci. 21: 520–522.

Richards, S.M. 1974. The concept of dominance and methods of assessment. Anim. Behav. 22:914–930.

Rowell, T.E. 1966. Hierarchy in the organization of a captive baboon group. Anim. Behav. 14:430–443.

Scheel, D.E., Graves, H.B., and Sherritt, G.W. 1977. Nursing order, social dominance and growth in swine. J. Anim. Sci. 45:219–229.

Sherritt, G.W., Graves, H.B., Gobble, J.L. and Hazlett, V.E. 1974. Effects of mixing pigs during the growing finishing period. J. Anim. Sci. 39:834–837.

Singer, F.J., Otto, D.K., Tipton, A.R., and Hable, C.P. 1981. Home ranges, movements and habitat use of European wild boar in Tennessee. J. Wildl. Manage. 45:343–353.

Stephens, D.B. 1980. Stress measurement in domestic animals. Adv. Vet. Sci. Comp. Med. 24:192-193

Stone, M.W. 1983. Cannibilism and other bad habits III. Western Hog Journal Winter/1983

Symoens, J. 1975. Psychic stress as a cause of post-weaning diarrhea in piglets. Appl. Anim. Ethol. 1:205 (abstract).

Symoens, J. and Van Den Brande, M. 1969. Prevention and cure of aggressiveness in pigs using the sedative Azaperone. Vet. Rec. 85:64-67.

Teague, H.S. and Grifo, A.P. 1961. Movement and resorting of pigs during the growing-finishing period. An. Sci. Mimeo 124. Ohio Agric. Exp. Sta.

Tindsley, W.E.C. and Lean, I.J. 1984. Effects of weight range at allocation on production and behaviour in fattening pig groups. Appl. Anim. Behav. Sci. 12:79-92.

Tisdell, C.A. 1982. Wild Pigs: Environmental Pest or Economic Resource? Pergamon Press. Sydney, Australia.

Van Kreveld, D. 1970. A selective review of dominance subordination relations in animals. Gen. Psychol. 81:143-173.

Whittemore, C.T. 1980. Pig Production. Longman Group Limited. New York. pp. 15-24.

Wilson, E.O. 1975. Sociobiology: The New Synthesis. Belknap Cambridge, Mass. pp. 279-297.

Winer, B.J. 1962. Statistical Principles in Experimental Design. McGraw-Hill, New York. pp. 88-89.

Wood, G.W. & Brenneman, R.E. 1980. Feral hog movements and habitat use in coastal South Carolina. J. Wildl. Manage. 44:420-427.

APPENDIX I

ECONOMICS OF MIXING FINISHING PIGS AT THE UBC SWINE FACILITIES

In calculating the extra costs of the various mixed treatments relative to the unmixed treatment, two main components can be identified. Given that the pigs start at a standard initial weight and are marketed at a predetermined finishing weight, the only difference between the treatments is 1) the amount of feed that must be fed in order for the pigs to achieve a common finishing weight and 2) the extra days that mixed pigs spend in the pens before the standard finishing weight is achieved.

A. FEED COSTS

Equation: F/G x (Common final weight - average starting weight) x Cost of feed = Total feed cost per pig

Where: F/G of unmixed groups = 3.35 kg/kg
F/G of 3:3 mixed groups = 3.74 kg/kg
F/G of Stresnil-treated groups = 3.85 kg/kg
F/G of 5:1 mixed groups = 3.65 kg/kg

Average starting weight = 76.218 kg
Weight after 21 days = 95 kg
Market weight = 102 kg

16% protein hog grower feed price
= \$ 187.54/tonne = \$ 0.188/kg

	To 95 kg	To 102 kg
Unmixed groups	: \$ 11.83/pig	\$ 16.24/pig
3:3 mixed groups	: \$ 13.21/pig	\$ 18.13/pig
Stresnil-treated groups	: \$ 13.59/pig	\$ 18.66/pig
5:1 mixed groups	: \$ 12.89/pig	\$ 17.69/pig

B. SPACE COSTS

a) Days to reach a standard final weight of 95 kg
(based on regression equations of average weight)

Unmixed groups	: 95 kg = 0.91823 t + 75.645 t = 21.08 days
3:3 mixed groups	: 95 kg = 0.91414 t + 74.050 t = 22.92 days
Stresnil-treated groups	: 95 kg = 0.86018 t + 74.674 t = 23.63 days
5:1 mixed groups	: 95 kg = 0.81500 t + 75:698 t = 23.68 days

Days to reach a market weight of 102 kg
(based on regression equations of average weight)

Unmixed groups	: 102 kg = 0.91823 t + 75.645 t = 28.70 days
3:3 mixed groups	: 102 kg = 0.91414 t + 74.050 t = 30.58 days
Stresnil-treated groups	: 102 kg = 0.86018 t + 74.674 t = 31.77 days
5:1 mixed groups	: 102 kg = 0.81500 t + 75.698 t = 32.27 days

b) Price for grower-finisher barn = $ 15.74/sq. ft. *
= $ 169.42/sq. m.

* A. Wahl, B.C. Min. Agric. Fish. Swine Specialist, 1987

c) Estimated average life of buildings = 20 years *
= 7305 days

* B.C. Pork Production Home Study Course, 1984

Equation: Days to Common final weight x Cost of pen space = Total space cost per pig

Where: Price per grower-finisher pen in U.B.C. Swine unit
= (1.91m x 3.48m)/pen x $169.424/sq. m.
= $ 1126.13/6 pigs/20 years
= $ 187.69/pig/7305 days
= $ 0.026/pig/day
(minimum cost estimate since the assumption is that 6 pigs occupy the pen at all times and are marketed simultaneously)

	To 95 kg	To 102 kg
Unmixed groups	**: $ 0.55/pig**	**$ 0.75/pig**
3:3 mixed groups	**: $ 0.60/pig**	**$ 0.80/pig**
Stresnil-treated groups	**: $ 0.61/pig**	**$ 0.83/pig**
5:1 mixed groups	**: $ 0.62/pig**	**$ 0.84/pig**

EXTRA COSTS ASSOCIATED WITH MIXING

		To 95 kg	To 102 kg
Unmixed groups			
Total Additional Cost	=	**$ 0.00/pig**	**$ 0.00/pig**
3:3 mixed groups			
Extra feed cost	=	$ 1.38/pig	$ 1.89/pig
Extra pen space cost	=	$ 0.05/pig	$ 0.05/pig
Total Additional Cost	=	**$ 1.43/pig**	**$ 1.94/pig**
Stresnil-treated groups			
Extra feed cost	=	$ 1.76/pig	$ 2.42/pig
Extra pen space cost	=	$ 0.06/pig	$ 0.08/pig
Drug cost ($ 5.25/20 ml) Recommended dose (1 ml/18.2 kg live wt.) = $ 1.10/pig (average 76.218 kg)			
Total Additional Cost	=	**$ 2.92/pig**	**$ 3.50/pig**
5:1 mixed groups			
Extra feed cost	=	$ 1.06/pig	$ 1.45/pig
Extra pen space cost	=	$ 0.07/pig	$ 0.09/pig
Total Additional Cost	=	**$ 1.13/pig**	**$ 1.54/pig**

These calculated costs are minimum estimates since the following costs have not been included:

1) labour associated with the extra days that mixed pigs spend in the pens,
2) medical treatment for pig(s) that sustain injuries or contract illnesses as a result of mixing and
3) extra pen space for sick and injured pig(s) should it be necessary to remove animal(s) to a separate pen until recovery is complete.