EFFECT OF SWINE DENSITY IN A GEOGRAPHIC AREA ON PRODUCTIVITY AND MORTALITY

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La croissance de l'industrie porcine de la Caroline du Nord (USA) a été marquée au cours des dix dernières années. Avec l'augmentation de la densité d'animaux dans certaines régions, la question concernant l'influence de la densité autour de ces régions sur la transmission des maladies et la productivité a été posée. Des études antérieures dans des industries de dindons et de porcs de la Caroline du Nord ont indiqué que des densités augmentées aux alentours de la ferme diminuaient les mesures de productivité.

Les données de production mesurant l'indice de conversion alimentaire, le gain moyen quotidien, la mortalité et les frais médicamenteux totaux provenant de 80 ateliers porcins d'engraissement en 1995 et 88 ateliers en 1996 ont été utilisées pour examiner les effets de la densité à 1, 2 et 5 miles aux alentours. D'autres facteurs affectant la productivité inclus dans cette étude ont concerné la taille du troupeau, l'époque de création de l'atelier et la génétique. Les résultats de régression univariés et multivariés sont présentés. L'adéquation du modèle était bonne pour toutes les variables résultats des 2 années avec des valeurs de R-carré comprises entre 0.438 et 0.836 en 1995 et entre 0.335 et 0.525 en 1996. La taille du troupeau a été un facteur significatif expliquant l'augmentation de FDC aussi bien que la diminution du GPD et LIV en 1996 mais n'a pas eu d'effet en 1995. L'augmentation de la densité dans un rayon de 1 mile autour d'une ferme a aussi permis d'expliquer la réduction de GDP en 1996 et MED en 1995. L'augmentation de la durée depuis le début de l'opération a été un facteur significatif expliquant des coûts réduits pour MED en 1996 et 1995. La durée avait une valeur de p égale à 0.058 pour FDC en 1995. La composition génétique était significative pour expliqer GPD et MED en 1996, et GPD et LIV en 1995. De plus, une interaction significative entre la génétique et la densité dans un rayon de 1 mile a été observée pour GPD, LIV et MED.

Growth of the swine industry in North Carolina, USA has been marked over the last ten years (Table 1). This growth has allowed North Carolina to jump from the 7th state in swine production in 1985 to the second largest swine producing state in 1996. Sampson and Duplin counties are the swine producing counties in the US. Growth has been produced by intensive hog production systems which can involve rearing of swine on 3 premises before marketing. Such farms with standardized management practices, genetics and feed across large systems of vertically integrated, contract based organizations. One farming system producing swine on 150 farms represents a structural innovation distinct from the traditional single unit, small volume production of swine. The development of concentrations of swine is a result of relative availability of land in Eastern North Carolina as the tobacco industry has ceased expansion, return on investment for the money borrowed for land purchase, economies of scale that result from large farms with 10,000 sows on a single premise and location within 60 miles of a feed mill. The rapid growth of in North Carolina sent hog number soaring from 2.8 million on 10,000 farms in December, 1990 to 9.3 million on 6,000 farms in 1996.

With increasing density of animals in a particular area, questions of whether surrounding area density affects disease transmission and productivity were raised. At first such questions were based on theoretical principles of disease ecology but were soon supported by antidotal field observations from producers, service personnel and company veterinarians. New producers did not want to locate in a very dense area because of concerns in achieving productivity goals. Initial observations on turkey farms in 1994 indicated a statistically significant effect of density on a weighted measure of performance (Fernandez, 1995). A first study in the swine industry also found a statistically significant effect on productivity parameters such as average daily gain, feed conversion, mortality and medication costs (Cowen, 1996). Such studies did include herdsize, were restricted by sex but did not include genetics as a factor. This study will examine a smaller more uniformly managed farming system to ascertain if productivity and surrounding area density are correlated under such conditions. Furthermore, measures for genetics and duration that the premises were in production will be included in the analysis.

MATERIALS AND METHODS

Production data for all finishing (fattening) premises for 1995 and 1996 from a single production company was assembled. This company began in 1991 and has grown rapidly to manage slightly over a million sows in 1997. The company had significant nutrition and disease problems in 1996, so each year's data was analyzed separately. Four production parameters were chosen for analysis: feed conversion efficiency, average daily gain, livability and total medication costs. Averages for all production cycles in a year were calculated. Explanatory variables were length of time the farm was in production, herdsize, density of swine in the surrounding areas and genetic composition on swine on the finishing floor. Density of swine in surrounding areas included all sows,

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nursery pigs housed in separate site facilities and finishing swine located within a 1 mile, 2 mile and 5 mile radius surrounding each farm in the data set. Densities were calculated using midyear estimates (July 1, 1995 and 96) using ARCINFO software with a SUN workstation.

Genetic composition consisted of 3 groups, some supplied by commercial breeding companies. Sex and building type were uniform. Descriptive statistics and univariate analysis was obtained with EXCEL software. Proc GLM in SAS was used to model the effect of independent variables (duration, herdsize, density in 1,2,5 mile surrounding areas and genetic composition) on the 4 production parameters for 1995 and 1996.

RESULTS

Density of swine surrounding farms for 1, 2 and 5 mile respectively was divided to form 3 equal groups of low, medium and high density. The univariate effect of density on productivity as measured by t-tests and analysis of variance results are given in Table I. Feed conversion and average daily gain were significantly worse in the most dense areas. This is in keeping to previous studies which showed a inverse dose response relationship between density and productivity (1, 2). A similar result was obtained for GPD and livability at a 1 mile radius density in 1996 (Table I).

Table I

The effect of density in varying areas surrounding finishing swine farms in North Carolina, 1995-1996

		TCAP (overall) Average Density	FCAP (overall) Average Density	+ Low Density Deviation from overall Mean	+ Medium Density Deviation from overall Mean	+ High Density Deviation from overall Mean	ANOVA F-Test for differences among groups (p value)	Pairwise T-test p<.05 L=Low M=Med H=High
FDC	Mile(s)							
1995	1	8228	7540	0.0164	-0.0146	-0.0016	0.4335 (0.6498)	
	2	18891	16307	0.0364	-0.0356	-0.0166	2.4529 (0.0927)	LM
	5	94627	74758	0.0484	-0.0116	-0.0366	3.8255 0.0261)*	LH
1996	Mile(s)							MH
	1	8633	7912	0.0090	0.0280	-0.0380	1.9507 (0.1485)	
	2	21255	18125	0.0410	-0.0270	-0.013	2.2515 (0.1115)	LM
	5	100854	81879	0.0310	-0.0170	-0.0140	1.2141 (0.3021)	
GPD	Mile(s)							
1995	1	8228 ^	7540	-0.0092	-0.0002	0.0098	0.3007 (0.7411)	
	2	18891	16307	-0.0132	0.0068	0.0078	0.4619 (0.6318)	
	5	94627	74758	-0.0352	0.0068	0.0288	3.8381 (0.0258)*	LH
1996	Mile(s)							LH,MH
	1	8633	7912	-0.0168	-0.0198	0.0372	4.2190 0.0179)*	
	2	21255	18125	-0.0068	-0.0008	0.0082	0.2115 (0.8098)	
	5	100854	81879	-0.0118	-0.0068	0.0182	1.0261 (0.3628)	
LIV	Mile(s)							
1995	1	8228 ^	7540	-0.0004	-0.0014	0.0016	0.1931 (0.8248)	
	2	18891	16307	0.0006	-0.0014	0.0016	0.2576 (0.7735)	
	5	94627	74758	-0.0034	0.0016	0.0016	1.1359 (0.3265)	
1996	Mile(s)							
	1	8633	7912	-0.0071	-0.0021	0.0089	6.3941 (0.0026)*	LH,MH
	2	21255	18125	-0.0031	0.0049	-0.0021	1.7266 (0.1841)	
	5	100854	81879	0.0009	-0.0021	0.0009	0.2235 (0.8002)	
MED	Mile(s)							
1995	1	8228 ^	7540	-93.4572	81.2388	15.2278	1.3741 (0.2592)	
	2	18891	16307	62.5118	-9.2582	-53.5962	0.6036 (0.5494)	
	5	94627	74758	91.8258	27.6738	-118.4742	2.1202 (0.1270)	
	Mile(s)							
1996	1	8633	7912	-42.9852	41.6228	-0.0732	0.3165 (0.7296)	
	2	21255	18125	-2.8202	-48.0332	52.5088	0.4493 (0.6396)	
	5	100854	81879	52.2758	19.0628	-71.9962	0.7280 (0.4859)	

* p value < 0.05 FDC=pounds of feed/pounds gained GPD=pounds of gain in finishing phase/days in finishing phase
LIV=Inverse of mortality for production cycle during finishing phase MED=Total medication cost per building
FCAP=Finishing Capacity TCAP=Total Capacity
\+ Calculation by subtraction of group mean from mean of all finishing floors (n=80, 1995) (n=88, 1996)
^ Same value as previous variable

Regression analysis results are given in table II. The fit of the model was good for all outcome variables in both years with r-square values ranging from .438 to .836 in 1995 and .335 to .525 for 1996. Herdsize was a significant factor explaining increased FDC, as well as decreased GPD and LIV in 1996 but had no effect in 1995. Increased density in a 1 mile area surrounding a farm also helped explain reduced GPD in 1996 and MED in 1995 . Increased time since the operation commenced (duration) was a significant factor explaining reduced costs for MED in 1996 as well as 1995. Duration had a p value of 0.058 for FDC in 1995. Genetic composition was significant in explaining GPD and MED in 1996, while explaining GPD and LIV significantly in 1995. Furthermore, a significant interaction occurred between genetics and density at a 1 mile radius for GPD, LIV and MED.

Table II
Multiple regression results of factors affecting production outcomes on North Carolina swine farms

Type III SS	FCAP Df=1	TC1MI Df=1	TC2MI Df=1	TC5MI Df=1	Duration Df=1	Genetic Df=2	TC1MI xGENE Df=2	TC2MIx GENE Df=2	TC5MIx GENE Df=2
	FDC 1995	**F-Test for Model = 3.36**			**p-value = 0.0008**		**r^2= 0.4385**		
Mean Sq.	0.0005	0.0049	0.0087	0.0110	0.0446	0.0086	0.0289	0.0099	0.0181
p-value	0.8392	0.5226	0.3970	0.3419	0.0581	0.4916	0.0979	0.4404	0.2278
	FDC 1996	**F-Test for Model = 2.88**			**p-value = 0.0022**		**r^2 = 0.3487**		
Mean Sq.	0.1796	0.0192	0.0163	0.0184	0.0334	0.0303	0.0110	0.0013	0.0040
p-value	0.0017*	0.2897	0.3293	0.2995	0.1638	0.1739	0.5253	0.9268	0.7884
	GPD 1995	**F-Test for Model = 5.30**			**p-value = 0.0001**		**r^2 = 0.5516**		
Mean Sq.	0.0100	0.0016	0.0042	0.0037	0.0092	0.0545	0.0263	0.0044	0.0044
p-value	0.1267	0.5422	0.3174	0.3483	0.1429	0.0001*	0.0033*	0.3567	0.3548
	GPD 1996	**F-Test for Model = 5.97**			**p-value = 0.0001**		**r^2 = 0.5256**		
Mean Sq.	0.0598	0.0355	0.0193	0.0077	0.0068	0.0304	0.0045	0.0021	0.0028
p-value	0.0025*	0.0182*	0.0793	0.2627	0.2939	0.0094*	0.4791	0.7139	0.6284
	LIV 1995	**F-Test for Model = 3.99**			**p-value = 0.0001**		**r^2 = 0.4806**		
Mean Sq.	6.04-E5	1.03-E5	0.0001	0.0001	5.86-E6	0.0010	0.0009	1.14-E5	1.51-E5
p-value	0.5828	0.8203	0.5028	0.4096	0.8639	0.0085*	0.0123*	0.9439	0.9268
	LIV 1996	**F-Test for Model = 2.72**			**p-value = 0.0037**		**r^2 = 0.3353**		
Mean Sq.	0.0068	0.0012	0.0013	5.80-E5	6.51-E5	0.0012	0.0009	0.0004	0.0003
p-value	0.0013*	0.1624	0.1515	0.7580	0.7442	0.1449	0.2217	0.5293	0.6413
	MED 1995	**F-Test for Model = 22.05**			**p-value = 0.0001**		**r^2 = .8366**		
Mean Sq.	67761.3 402	139164 0.2143	30684.9 523	135728. 1011	656696. 4611	13462.4 239	736602. 9241	11999.7 363	51839.8 049
p-value	0.1701	0.0001*	0.3537	0.0541	0.0001*	0.6831	0.0001*	0.7118	0.2369
	MED 1996	**F-Test for Model = 4.33**			**p-value = 0.0001**		**r^2 = 0.4459**		
Mean Sq.	251896. 5997	91.5443	76876.5 776	99615.4 531	136230 6.6594	467049. 8166	21743.4 758	156221. 5609	298986. 8267
p-value	0.1253	0.9765	0.3943	0.3326	0.0006*	0.0150*	0.8129	0.2318	0.0642

* p-value < 0.05 FDC=pounds of feed/pounds gained GPD=pounds of gain in finishing phase/days in finishing phase
LIV=Inverse of mortality for production cycle during finishing phase. MED=Total medication cost per building.
FCAP=Finishing Capacity TC(1,2,5)MI=Total Capacity in 1,2,5 mile areas

CONCLUSIONS

Univariate results showed increased density at 1 mile to be associated with increased productivity in contrast to previous studies. The previous result looked at 2 mile surrounding areas. However, at 10 mile surrounding area density, we have found a 23 fold increase in both herds and total population for the farming system. in our original studies and compared to the present data set. Further studies on at what distance density has it's greatest effect are needed. Our previous studies did not consider genetics. However, it is important to note that with the inclusion of genetics into a multiple regression analysis in this present dataset, we explained more of the variability in production outcomes. Additionally, the regression signs indicate that increased density reduces productivity as in previous studies. Factors affecting productivity were different for the two years. In 1995, every production parameter showed an interaction with genetics and density. In 1996, the swine farms had problems with nutrition and disease. Simultaneously, the factors affecting productivity shifted to emphasize finishing capacity on farm (FCAP). Future studies should include temperature, initial placement weights, as well as incremental distances in surrounding area density measurements.

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