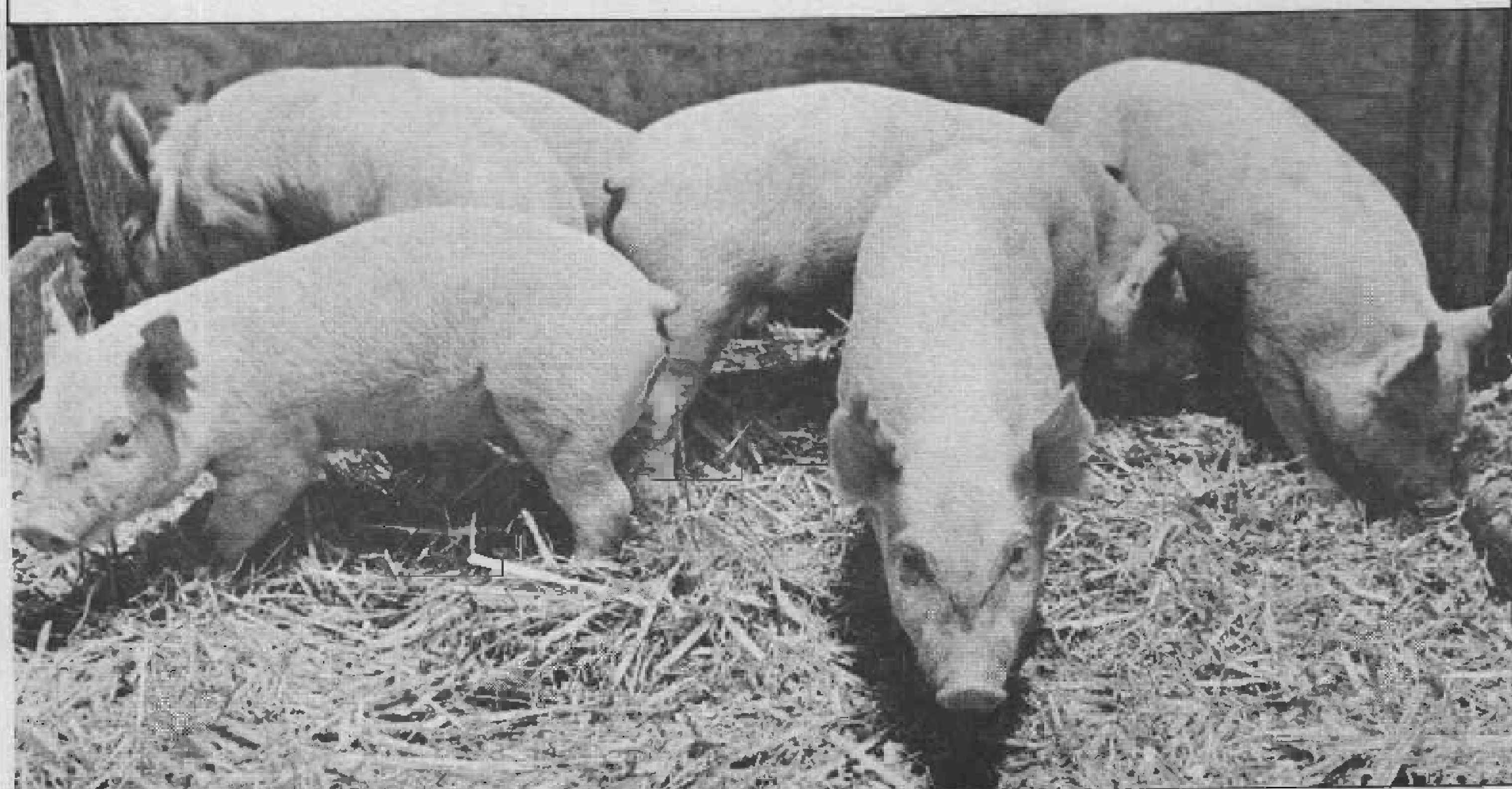
Reports of the sixteenth annual

SWINE DAY



Special Report 426, December 1974
Agricultural Experiment Station
Oregon State University, Corvallis

SIXTEENTH ANNUAL OSU SWINE DAY

December 7, 1974

Withycombe Auditorium

MORNING SESSION:

8:45 am	Resistration
9:30 am	Welcome: Dr. J. E. Oldfield, Head, Department of Animal Science
9:45 am	Swine A.I. Using Frozen Semen - Film and Comments - H. R. Burkhart (Film supplied courtesy of East Central Breeders, Waupun, Wisconsin.)
10:30 am	Some Aspects of Swine Research Concluded and of Other Research in Progress - D. C. England
11:00 am	The Pig's Air Environment - S. E. Curtis
11:50 am	LUNCH - Withycombe Auditorium - Served by Withycombe Club

AFTERNOON SESSION:

1:00 pm	Current Swine Nutrition Research at OSU - P. R. Cheeke
1:30 pm	Management to Improve Feed Efficiency - P. B. George
2:00 pm	New Concerns in Swine Waste Management - R. J. Miner
2:30 pm	BREAK
2:45 pm	Production Information Exchange Among Producers - Coordinated by John Leffel, Extension, Washington County
3:15 pm	Questions for Speakers
3:45 pm	ADJOURN

COVER: This litter of seven pigs in the Oregon State University herd was produced by artificial insemination. The frozen semen used was shipped by bus from Wisconsin.

CONTENTS

SWINE ARTIFICIAL INSEMINATION USING FROZEN SEMEN

H. R. Burkhart 1

SOME ASPECTS OF SWINE RESEARCH CONCLUDED AND OF OTHER RESEARCH IN PROGRESS

D. C. England 3

THE PIG'S AIR ENVIRONMENT

S. E. Curtis 7

CURRENT SWINE NUTRITION RESEARCH AT OSU

P. R. Cheeke 10

MANAGEMENT TO IMPROVE FEED EFFICIENCY

P. B. George and D. C. England 13

NEW CONCERNS IN SWINE WASTE MANAGEMENT

R. J. Miner and L. Boersma 16

SWINE ARTIFICIAL INSEMINATION USING FROZEN SEMEN

H. R. Burkhart

There have been some important recent advances made in the area of artificial insemination of swine with frozen semen.

It was in 1949 that workers in England found that glycerol was an effective protectant for the preservation of life in spermatozoa frozen at very low temperatures. Soon after this discovery bull semen was successfully frozen in a solution containing egg yolk and glycerol at dry ice temperature (-79 degrees C), thawed, and used for insemination with satisfactory fertility results. This early method was refined by additional research and bull semen frozen with and stored in liquid nitrogen at -196 degrees C is now routinely used to artificially inseminate millions of cows throughout the world each year.

The sperm of other animals has not retained fertilizing capacity after freezing and thawing as readily as has that of the bull--when procedures and methods developed for bull semen have been used. It appears that different extenders and methods of freezing and thawing must therefore be developed for each species to obtain optimum results in A.I. work. This seems to be a valid statement at present and will surely be valid until (and if) some optimum extender and freezing method is discovered in the future that will work with all species.

Relatively few experiments on the freezing of boar spermatozoa were reported prior to 1971. Since that time, considerable progressive work has been accomplished and reported upon by Graham et al (1971a), Graham et al (1971b), Pursel and Johnson (1971), Pursel et al (1972), Crabo et al (1972) and Bower et al (1973).

The work of these researchers and that of others not mentioned here has shown that boar spermatozoa are damaged by the presence of glycerol in the dilutor used to extend and freeze boar semen. Glycerol has customarily been used as a "life-protector" to protect spermatozoa from suffering lethal freezing damage. As a life-protector, glycerol preserves both motility and fertilizing capacity during the freezing of bull sperm --but only motility is preserved in the case of boar spermatozoa when glycerol is added to the freezing medium. Bowers et al (1973) also propose that glycerol may impair normal sperm transport in the uterus of the sow.

The recent successes that have been achieved with the use of frozen boar semen are believed to have been obtained by using frozen boar semen

---

H. R. Burkhart, Research Associate, Department of Animal Science, Oregon State University.

not containing glycerol. The semen has been frozen in pellet form on a block of dry ice and then stored in liquid nitrogen. It is pelleted in a concentrated form and stored in cardboard tube containers in liquid nitrogen. In this form it may be shipped to the field, with frozen semen extender also shipped in a separate insulated box. Thawing and inseminating procedures are essentially simple.

Swine insemination procedures are simpler, in some respects, than are the procedures used with the cow. Because of this the correct insemination techniques should not be difficult to learn. The ability to detect heat accurately and to time insemination accordingly is considered to be the chief management factor in making swine A.I. successful. Due to the fact that the sow normally shows outward signs of heat, the correct timing of insemination should not be a serious limiting factor in fertility. Success achieved to date seems to indicate that two inseminations per heat period improve conception rate. The first insemination is generally made at the onset of standing heat and the second insemination 12 to 24 hours later.

It seems likely that we will hear much more about swine A.I. with frozen semen. If conception rates can be improved to approach those obtained with natural mating, this procedure may become as important to the swine industry as it has been to dairying.

References

1. Bower, R. E., B. G. Crabo, M. M. Pace and E. F. Graham. 1973. Effects of dilution and glycerol on the release of glutamic-oxaloacetic transaminase (GOT) from boar spermatozoa. J. Anim. Sci. 36:319.

2. Crabo, B. G., K. I. Brown and E. F. Graham. 1972. Effect of some buffers on storage and freezing of boar spermatozoa. J. Anim. Sci. 35:377.

3. Graham, E. F., A. H. J. Rajamannan, M. K. L. Schmehl, M. Maki-Laurila, and R. E. Bower. 1971a. Preliminary report on procedure and rationale for freezing boar-semen. A. I. Digest 19(1):12.

4. Graham, E. F., A. H. J. Rajamannan, M. K. L. Schmehl, M. Maki-Laurila, and R. E. Bower. 1971b. Fertility studies with frozen boar spermatozoa. A. I. Digest 19(6):6.

5. Pursel, V. G. and L. A. Johnson. 1971. Fertility with frozen boar spermatozoa. J. Anim. Sci. 33:265. (Abstract).

6. Pursel, V. G., L. A. Johnson and G. B. Rampacek. 1972. Acrosome morphology of boar spermatozoa incubated before cold shock. J. Anim. Sci. 34:278.

SOME ASPECTS OF SWINE RESEARCH CONCLUDED AND OF OTHER RESEARCH IN PROGRESS

David C. England

Two swine research undertakings have been concluded during the past year. One, the swine breeding project, has been in existence for the past twelve years. During this time it has focused attention on numerous facets of achieving improved performance through breeding. Some findings have been:

1. Performance testing methodology is important in accurately identifying superior individuals. Two examples are:

    (a) It is important that pigs be performance tested for growth rate from the same starting weight to the same finish weight rather than for a standard period of time. This was shown by evaluating individual weight gains from 56 days of age to 154 days of age vs. rate of gain from 60 to 200 lbs. The top 20 gilts were "selected" on the first basis; the top 20 (from the same group of gilts) were then "selected" on the second basis. Only 13 of the gilts that were selected on the first basis were included among the 20 selected on the second basis. Performance data are shown in table 1 as reprinted from Oregon State University Agricultural Experiment Station Special Report No. 227. These results indicate that one-third of the top 20 gilts selected for growth rate by the first method were selected because they were heavier at weaning, not because they were capable of faster growth after weaning. Heavy weaning weight is desirable, but differences in weaning weight are controlled more by environment and less by heredity than are differences in average daily gains after weaning when these are measured from a uniform starting weight to a uniform ending weight. Unless tested from the same starting weight, pigs from the largest litters would be discriminated against because they tend to weigh less at weaning, which in turn would cause them to be older at market weight.

    A recent analysis (George and England, 1973) showed that gilts that were small at birth but which were selected on the basis of their performance merit farrowed as many pigs in their first litters at as young an age as did their litter mates of heavier birth weights. An earlier study (England, 1969) showed that gilts selected for high performance but which had inadequate litter size in their first litter subsequently farrowed as many pigs per litter as those gilts that farrowed adequately in their first litters. Culling on the basis of first litter size is thus not highly accurate. These data are shown in table 2.

D. C. England is Professor of Animal Sciences at Oregon State University, Corvallis.

TABLE 1. ANIMALS IN THE SAME HERD WITH HIGHEST AVERAGE DAILY GAINS (By two methods of performance testing.)

Age-constant basis[1]			Weight-constant basis[2]		
Animal no.	Average daily gain	56-day weight	Animal no.	Average daily gain	56-day weight
	lbs.	lbs.		lbs.	lbs.
1	1.97	44	3	2.19	36
2	1.94	40	1	1.98	44
3	1.93	36	7	1.96	36
4	1.90	39	4	1.93	39
5	1.86	46	2	1.91	40
6	1.85	35	--*	1.90	31
7	1.84	36	16	1.89	31
8	1.82	40	18	1.86	26
9	1.79	30	19	1.86	28
10	1.77	32	8	1.85	40
11	1.74	38	--*	1.84	27
12	1.69	33	9	1.84	30
13	1.69	42	5	1.82	46
14	1.68	41	--*	1.80	27
15	1.67	25	--*	1.79	38
16	1.67	27	--*	1.78	27
17	1.67	27	15	1.78	25
18	1.67	31	--*	1.75	41
19	1.67	41	17	1.75	29
20	1.66	28	--*	1.74	38
Average:	1.77	35.6		1.86	34.3

[1] 56-154 days.

[2] 60-200 lbs.

*The animal was not in the top-performing group on age-constant basis.

TABLE 2. COMPARISON OF NUMBER BORN IN FIRST LITTER WITH AVERAGE OF SECOND, THIRD AND FOURTH LITTERS

No. born alive		No. born alive		No. born alive	
1st Litter	Average of 2nd,3rd,4th Yorkshires	1st Litter	Average of 2nd,3rd,4th Crossbred	1st Litter	Average of 2nd,3rd,4th Berkshires
6	6.0	6	11.0	6	6.5
7	11.0	7	12.0	7	7.1
8	10.5	8	10.0	8	7.9
9	10.0	9	10.7	9	8.9
10	9.2	10	12.1	10	8.4
11	9.5	11	11.0	11	9.6
12	11.0	12	10.3	12	---
13	9.5	13	12.3	13	8.0
14	11.7	14	----	14	---

(b) It is usual to test for feed efficiency by use of a sample of pigs from a litter or by testing the entire litter as a group. In either case, differences for feed efficiency among individuals are not known; all pigs in the litter are assumed to have the same feed efficiency. It would be surprising if this were so; individuals should be expected to vary as much for feed efficiency as for growth rate or leanness. Because groups of pigs on test show a correlation of about 0.80 between average daily gain and feed efficiency, it is generally assumed that selection of the fastest gaining individuals from the most efficient litters will generally result in selection of individuals with most efficient feed usage. Individual testing of 69 pigs for individual feed efficiency and for average daily gain showed that this dependence would lead to selecting the wrong individual for feed efficiency in approximately one out of four choices. Because of the cost of individually feeding large numbers of pigs, this degree of error has been tolerable. With the prospect of feed resources becoming increasingly scarcer and proportionately more costly, it may be timely to re-evaluate the economic feasibility of individual testing of boar candidates for feed efficiency as well as for growth rate and leanness.

The genetic studies have shown consistent advantages for crossbreeding. Analysis of data accumulated during the five year period, 1968-73, shows 15% superiority of crossbred dams over the average of the parents for number of pigs born and 21% increase in the number of pigs weaned. Purebred dams have shown improvement in litter size when mated to produce crossbred pigs; this improvement is less than achieved by the use of crossbred dams.

2. The studies on feeding lactic acid bacteria, stored in frozen concentrated form, to reduce scouring in suckling and weaned pigs is completed until further resources become available. This research has shown mixed results. The concept was that: (1) scouring was caused largely by E. coli; (2) a competing organism in the digestive system would reduce the number and proportion of E. coli; and (3) that these changes in the microorganism population would result in reduced incidence and severity of scouring.

Several experiments were conducted (Sheggeby, 1974). These were consistent in showing a marked reduction in number and proportion of E. coli as a result of ingestion of the lactobacillus organism by direct feeding or through the drinking water. This result occurred both with and without antibiotics in the ration. Favorable results on gains and decrease in incidence and severity of scouring occurred in the experiment that included use of antibiotics but not in the experiment in which the ration did not include antibiotics. Sows that were fed the lactobacillus organisms during gestation showed no difference in numbers or proportions of E. coli compared to control sows, and suckling pigs from the two groups of sows had similar bacterial profiles and weight gains.

Research is continuing on the initiation of expression of estrus in gilts in confinement by subjecting them to management changes. In these studies, exposure to a boar(s) appears to cause occurrence of ovulation in gilts weighing 180 to 200 pounds. Some of these gilts exhibit symptoms of estrus but others do not. The maximum response to date (87.5% showing ovulation within two weeks) has been achieved by mixing gilts with others unfamilar to them and providing constant exposure to a boar (Schiemann, 1974).

REFERENCES

George, P. B. and D. C. England. 1973. Mating and conception adequacy in gilts bred at first observed estrus. 15th Ann. Swine Day, Ore. Agr. Expt. Sta. Spec. Rep. #398, pp. 27-31.

England, D. C. 1969. Factors affecting sow productivity. Mimeograph; 11th Ann. Swine Day, Ore. State Univ.

Sheggeby, Gene G. 1974. Effect of feeding concentrates of Lactobacillus Lactis on fecal bacterial flora, scouring, and weight gain in swine. Ph. D. Thesis, Ore. State Univ.

Schiemann, Calvin A. 1974. Personal communication.

THE PIG'S AIR ENVIRONMENT

Stanley E. Curtis

Wastage cuased by respiratory disease has been estimated to be as high as $2 per hog nationally. Results of a controlled experiment indicated that even very mild pneumonia reduced the rate of gain about 10 percent, and that the reduction was proportional to severity of pneumonia; very severe pneumonia reduced rate of gain about 30 percent. It is suspected that adverse factors in the thermal environment influence incidence and severity of pneumonia by predisposing pigs to the disease. But, there are other possible determinants of respiratory disease in swine.

The trend toward more-or-less enclosed confinement and year-round production continues in the pork-production industry. The air in enclosed swine houses is polluted with dust, microbes, gases, and odorous compounds that arise from the feed, the waste, and the pigs themselves. What is the nature of the pig's air environment? Do air-environmental factors influence incidence and severity of respiratory disease in swine? Should we consider controlling levels of air-environmental factors in swine environments? During the past several years, we have attempted to increase our knowledge of the character of the air environment inside swine houses and to learn whether air pollution such as that which occurs in swine houses affects the health and performance of swine.

Following are some of the questions we have asked during the course of these studies. Accompanying the questions are summaries of the answers we have found.

1. How much dust is there in swine-house air?

Dust level was measured a total of 178 times over 15 months in four enclosed gestation or gestation-farrowing-lactation houses at the University. Values ranged from 51 to 11,482 μg of dust per cubic meter of air. The average was 1,326 μg per cubic meter. Aerial dust level in enclosed swine houses tended to be higher at commercial pork-production operations (4,960 μg per cubic meter on average), and it was higher in growing-finishing houses than in farrowing-lactation houses (12,735 vs. 2,163). The threshold limit value for human industrial occupancy (40 hours per week) as established by the American Conference of Governmental Industrial Hygienists is 10,000 μg of inert dust per cubic meter of air.

2. What is the bacterial level in swine-house air?

The concentration of bacterial-colony-forming particles was measured a total of 192 times over 15 months in the same four enclosed swine houses at the University as above. Values ranged from 5,888 to 1,122,018 bacterial-colony-forming particles per cubic meter of air.

S. E. Curtis is Associate Professor of Environmental Physiology in the Department of Animal Science, University of Illinois at Urbana-Champaign.

The average was 102,920 per cubic meter. Aerial bacterial-colony-forming particle level in enclosed swine houses tended to be higher at commercial pork-production operations (282,380 per cubic meter), and it was higher in growing-finishing houses than in farrowing-lactation houses (758,578 vs. 141,254). The aerial concentration of bacterial-colony-forming particles outdoors is commonly 100 per cubic meter.

3. Do aerial dust and bacterial levels in swine houses change with time?

With the all-in, all-out system in the enclosed farrowing houses at the University, roughly hundredfold straight-line increases in aerial bacterial level during a month-long farrowing period have been observed. In a study of the air in two enclosed weaning houses at the University, there was little evidence of a daily cycle in the aerial level of bacterial-colony-forming particles. In studies of the four enclosed gestation and gestation-farrowing-lactation houses at the University over 15 months, aerial levels of both dust and bacterial-colony-forming particles were inversely related with median outside temperature; the lower the outside temperature, the higher the levels of these air pollutants. Thus, air pollution in swine houses tends to be higher in the winter than in the summer, probably largely because ventilation rate is generally reduced during cold weather.

4. Are dust and bacterial levels in swine-house air related?

The levels of dust and bacterial-colony-forming particles in swine-house air tend to be directly related.

5. What kinds of bacteria occur in swine-house air?

Ten swine houses at commercial operations and four at the University were studied a total of sixteen times to determine concentrations of aerial bacterial particles that form colonies on a general medium and on special media for staphylococci, fecal streptococci, and coliforms. The ratio of the bacterial-colony-forming particle count on the special medium for staphylococci to that on the general medium was 0.36; on the special medium for fecal streptococci compared to the general medium, 0.13; and on the special medium for coliforms compared to the general medium, less than 0.01.

6. What sizes are aerial bacterial-colony-forming particles in swine-house air?

Only a third of the inhaled particles 6 μm in aerodynamic diameter reach and deposit in the lungs (two-thirds deposit in upper-respiratory passages), whereas almost all inhaled particles 3 μm or smaller reach and deposit in the lungs. Hence, in regard to particulate challenge to the lungs, particles less than 5 μm in diameter, and especially those less than 3 μm in diameter, are important. Average percentages of bacterial-colony-forming particles that were less than 4.7 μm or less than 3.3 μm in aerodynamic diameter were 31 percent and 15 percent, respectively, in enclosed swine houses at the University and 28 percent and 11 percent respectively, in enclosed swine houses at commercial pork-production operations. The proportion of bacterial-colony-forming particles that were lung-depositable was not affected by total aerial concentration of the particles. Twenty-one percent of the staphylococcal and streptococcal-colony-forming particles, respectively, and 9 percent of the coliform-colony-forming particles, were less than 4.7 µm in aerodynamic diameter.

7. Do atmospheric ammonia, hydrogen sulfide, or dust reduce the rate of gain in healthy pigs?

Ammonia ordinarily occurs at concentrations less than 50 parts per million in swine-house air. Ammonia alone at 50 or 75 parts per million had little effect on the growth performance of healthy pigs. Only when aerial dust was applied at a very high level (300,000 µg per cubic meter) did it affect pig performance; at the level more commonly encountered in practice (10,000 µg per cubic meter), it had no effect. The effect of aerial dust and ammonia were additive; aerial dust did not increase ammonia's assault on the pigs. Hydrogen sulfide ordinarily occurs at concentrations less than 2 parts per million in swine-house air. Hydrogen sulfide, either alone at 8.5 parts per million or at 2 parts per million in combination with ammonia at 50 parts per million, had little effect on the rate of gain or on feed efficiency in healthy pigs. All of the pigs studied in the seven trials in which effects of air pollutants on swine performance were assessed were sacrificed for complete post-mortem examination on the day they were taken off trial. Samples of various tissues, with particular emphasis on the respiratory tract, were also taken for subsequent processing and microscopic examination. No evidence was found of consistent gross or microscopic structural alterations resulting from any of the air-pollution treatments.

8. Does atmospheric ammonia reduce the ability of the pig's lungs to resist bacterial infection?

Littermate pairs of young pigs were exposed for 10 minutes to air containing aerosolized *Escherichia coli* of a nonpathogenic strain. The bacteria deposited in the pigs' lungs during this loading period. Immediately following the loading period, one pig from each pair was placed in an air-polluntant exposure chamber in which the ammonia concentration was held at 50 parts per million, and the other pig was placed in a control chamber. After a two-hour period, during which the bacteria were cleared by various mechanisms from the pigs' lungs (as evidenced by a reduction in the concentration of viable bacteria in the lungs), there were on average, half again as many bacteria remaining in the lungs of pigs exposed to ammonia during the clearance period as in those kept in the control chamber. The pigs held in the high-ammonia environment were evidently less able to clear bacteria from their lungs. This effect may not be the same for all bacterial species, and may be due to a non-specific response to any stressor. For instance, we have found that cold stress also reduces the youngs pig's rate of pulmonary bacterial clearance.

CURRENT SWINE NUTRITION RESEARCH AT OSU

P. R. Cheeke

The non-ruminant nutrition research program at OSU is directed toward the development of new feed sources for swine. Increasing emphasis on the direct use of high quality feedstuffs (grains, soybeans, etc.) in human diets rather than as animal feed suggests that a major role of livestock in the future will be the conversion of products unsuitable for direct human consumption into high quality animal protein. Materials formerly regarded as waste products will increasingly be considered in terms of their feeding value. Our work at OSU is concerned with the development of some of these new feed sources. The major areas of emphasis at present are:

1. Improved utilization of alfalfa as a protein source.

2. Evaluation of a protein supplement from a new oilseed crop, Limnanthes alba (Meadow Foam).

3. Development of a protein source from human and animal wastes.

4. Development of a feed grain specifically designed for swine feeding.

Each of these research projects will be briefly described.

1. Use of Alfalfa as a protein source.

Alfalfa has great potential as a protein source for swine, in that it produces more protein per acre than any other crop.

Direct use of alfalfa as the major protein supplement for feeder pigs is not feasible. High levels of alfalfa are unpalatable, causing reduced feed intake, and the digestibility of the protein is low. The protein in dehydrated alfalfa has less than 50% digestibility in swine.

Recently a method of isolating alfalfa protein has been developed. This material, containing 40-60% crude protein, is prepared by pressing the juice out of green alfalfa, and concentrating the protein in the juice. Preliminary results on the use of alfalfa protein concentrate (APC) in swine rations were reported last year at Swine Day. The major results are summarized:

a. In grower-finisher rations, APC was equivalent to soybean meal as a protein source. Complete replacement of soybean meal by APC had no adverse effect on performance.

Peter R. Cheeke, Associate Professor, Department of Animal Science, Oregon State University

b. With baby pigs, APC was tested at levels up to 34% of the ration. In general, it gave results comparable to those obtained with soybean meal.

c. APC was highly palatable at all levels tested.

d. No adverse effects from its use were noted.

If and when a processing plant to produce APC in the Northwest is established, or if on-the-farm processing units become available, APC can be expected to become an important protein supplement for swine. Our work has established its potential value as a replacement for soybean meal.

Although alfalfa protein concentrate is not yet available commercially, potential does exist for greater use of alfalfa meal (sun-dried or dehydrated) in swine rations as a protein source. For sows, increased use of alfalfa in gestation rations may be profitable. A recent Nebraska study indicated that sows were successfully kept through three gestation periods on an alfalfa hay diet.

2. Evaluation of Limnanthes meal as a protein supplement.

The OSU Department of Farm Crops is investigating a potential new oilseed crop, Limnanthes alba (Meadow foam). Limnanthes oil is one of the few possible replacements for sperm whale oil, which will disappear from commerce by 1976. Both these oils form bonds with metal, thus providing excellent lubrication in under-water situations, high speed applications, etc. Successful development of a facility to extract Limnanthes oil in Oregon would result in the production of Limnanthes meal as a by-product. The feeding value of this meal is currently being evaluated. Preliminary studies indicate that it is inferior to soybean meal, and similar to cottonseed meal, in protein quality. One of the problems associated with its use is the presence of toxic compounds, which cause enlargement of the thyroid gland (goiter). Methods to reduce or eliminate the toxic properties of Limnanthes meal are under investigation. The problem is not insurmountable, since other proteins (rapeseed meal, mustard meal) also contain thyroid inhibitors that can be removed by processing. The results obtained so far in nutrition studies indicate that if commercial development of this crop occurs, the meal could be profitably employed in livestock feeding.

3. Development of a protein source from human and animal wastes.

Immense quantities of nutrients are wasted in North America, because of our inefficient recycling of human and animal wastes. Methods to utilize these nutrients in animal feeding must overcome objections from an aesthetic point of view, as well as ensure that no threats to human health occur.

For two years, we have been investigating the potential of activated sewage sludge as a protein source. It contains about 35% crude protein.

While our studies have indicated that it provides useful amounts of protein, relatively high levels of heavy metals in the sludge will probably make the material unacceptable for animal feeding. An alternate approach currently being examined is the culturing of organisms on the sludge, and harvesting these as animal feeds. Both algae and fish (carp) are potential candidates for transforming the tremendous nutrient potential of sewage sludge into an acceptable animal feed.

We are cooperating with researchers in the OSU Department of Soils in a study of the recycling of swine wastes by means of growing algae on swine lagoon liquid, and harvesting the algae as a protein source. A pilot plant is being constructed at the Swine Center. Our nutritional studies with algae produced on swine wastes have shown it to be an excellent protein source. The major problem in commercial exploitation of this concept will be the development of an economically feasible way of harvesting the algae.

4. Progress in Development of Feed Grains

The plant breeding program to develop feed grains specifically tailored for animal feeding needs was described at Swine Day last year. Potential exists for increasing the protein content of feed grains, as well as improving amino acid balance (protein quality).

A rat bioassay has been established to evaluate samples of grains produced by the plant breeders. Corn, wheat and barley are being evaluated. The rat feeding program involves comparing the grain samples in test diets that contain the same protein level, with all the dietary protein from the grain. Thus differences in growth rate are due to differences in the quality of the grain protein. A "grain protein score" has been devised that takes into account both the protein quality, and the % protein of each sample. In general, the samples with lower crude protein contents have tended to be of superior protein quality. Since the ideal feed grain will have a high content of high quality protein, selection for protein level alone would not be adequate.

In the future, livestock will undoubtedly be in greater competition with humans for traditional feedstuffs. Increasing emphasis on the use for livestock of by-products and waste materials not suitable for direct human consumption can be expected. The nutrition program at OSU is and will continue to be oriented toward investigation of these types of materials as new animal feedstuffs.

MANAGEMENT TO IMPROVE FEED EFFICIENCY

P. B. George and D. C. England

The cost of feed is estimated to be 70 to 85 percent of the total cost of producing pork. With the present high cost of feed, it is timely to examine possible ways to reduce the feed required to maintain the breeding herd during gestation and lactation and to produce market hogs.

There are genetic differences in ability to utilize feed efficiently; some individuals can produce more weight gain on a given amount of feed than others. Selection of breeding animals on the basis of performance test for feed efficiency is expected to result in achievement of about one-third as much improvement in the offspring as was shown by the superiority of parents if males and females are both selected on this basis. If only males are selected for feed efficiency improvement is less rapid; but more than half as rapid because more selection pressure is possible in boars because so few are needed. The improvement achieved is permanent unless subsequent selection is relaxed and animals of inferior genetic ability are again used in the herd. Because sires have a cumulative effect on the heredity of the herd that makes them collectively much more than half the herd over a period of two or more generations, it is especially important that sires be selected for excellent feed efficiency.

A boar used in a year-round farrowing program could sire 1000 pigs per year. If the boar used required three-tenths of a pound less feed per pound of gain than other boars available, this would amount to 60 pounds superiority from birth to 200 pounds. When mated to similar females, this boar would be expected to produce offspring that received one-third of this sire's superior capacity for less feed required per unit of gain. Because the offspring receive only half of their heredity from the sire, and their dams were equal to the dams bred to other boars, the offspring would be expected to possess about one-sixth of the superiority shown by the boar. This would be a saving of about ten pounds of feed from birth to market for each pig. If 1000 pigs were marketed from this boar, the feed savings would be five tons -- achieved just by selecting the right sire, and with no other additional production costs.

Lean hogs use less feed per unit of gain than fat hogs. Data from various sources indicate that lean, fast growing hogs in a herd use an average of about .2 pounds less feed per pound of gain than fatter hogs in the herd with similar growth rates. This amounts to about 40 pounds less feed required to produce a lean market hog. This is a saving of two tons of feed for each 100 market hogs -- at no extra cost and achieved just by selecting lean, fast growing breeding stock.

Feed wastage due to improper feeder regulation is a common source of increased feed cost. Wastage of only a few tenths of a pound of feed per pig per day results in significant total feed wastage and increased feed cost. One study (Hormel Farmer - date unknown) showed a loss of .35 lbs of feed per pound of gain -- 70 pounds to produce a market hog -- from non-serviced feeders vs. frequently serviced ones.

P. B. George is Graduate Research Assistant and D. C. England is Professor, Department of Animal Science, Oregon State University.

Rations that are deficient in any of the needed nutrients results in increased pounds of feed required per pound of gain. It is not useful to "fortify" rations with amounts of any nutrients beyond the pigs needs for them, but careful attention to supplying optimum amounts in proper balance is especially important in times of high ration costs.

Some degree of restriction of feed intake is widely practiced in Great Britian and the Scandinavian countries to obtain increased feed efficiency and leaner carcasses. Two contrasting principles are involved: (1) weight gains are produced only by feed intake in excess of body maintenance requirements; this leads to more efficient gains with increased daily feed intake because a lower percentage is used for maintenance as feed intake increases; (2) the appetite of pigs results in feed intake in excess of the amount that can be developed into lean tissue gain; this excess is stored as fat. Storage of feed energy as fat requires more feed per unit of gain than does development of lean tissue gain because fat is a concentrated form of energy storage.

Restriction of feed intake should take into account both of these relationships; any restriction should seek to find the maximum combination of reduction of fat storage and avoidance of severely increased percentage requirement of the feed intake for maintenance rather than growth.

Restricted intake of rations of high energy content is more successful than restriction of rations of low energy content. Likewise, restriction of feed intake is more successful with pigs that tend toward excess fatness than for lean pigs. Sex of pig is also important; barrows tend to be fatter than gilts. If feed is to be restricted, it is usually more effective to pen barrows and gilts separately and restrict feed intake for gilts less -- if at all -- than for barrows. Restriction of feed intake usually requires changes in feeding procedures that tend to decrease the economic gain resulting from feed savings.

Herd health is of utmost importance in achieving feed efficiency. It is difficult to attach specific cost figures to outbreaks of pneumonia, scouring, atrophic rhinitis, internal and external parasites, and other conditions that rob pigs of vibrant health. The cost, however, is two-pronged: the cost of treatment, and the cost of the loss of performance resulting in low gains per unit of feed used. To avoid herd health problems, every facet of managerial responsibility must be exercised. Utilization of SPF type herd operation can be helpful in avoiding chronic as well as contagious diseases.

Ration preparations as well as ration nutrient content can influence feed efficiency. Preparing a complete ration in meal or pellet form is more efficient than "free choice" of ingredients by the animals. Pelleting rations generally decreases feed required per unit of gain compared to rations in meal form. Cost of pelleting is a lesser proportionate cost of the ration as price of ration increases, and the magnitude of feed cost reduction due to increased efficiency is greater when ration cost is high even though the percentage improvement in feed efficiency remains the same.

Feeding less energy during gestation has become a near standard practice in recent years. The purposes of gestation feeding are: (1) to maintain a high proportion of the embryos and develop them into full term piglets that have vigor and stamina that permit and enhance post-natal survival and growth, and (2) to prepare the dam for effective lactation. To achieve these purposes, it is important to recognize that the requirements for minerals, vitamins and protein are still as much as they were with higher energy intake. These must be supplied in the reduced allotment of feed; percentages of these nutrients in the ration will thus need to be increased because of the decreased pounds of total ration fed daily.

Reduction of feed cost can at times be achieved by use of higher proportions of alfalfa in the gestation ration than are generally used. There is both recent and not-so-recent research that documents favorable gestation results with rations that contain high levels of alfalfa.

Prudent feeding during lactation offers some potentials for decreasing feed costs. Dams nursing ten or more pigs require essentially full feeding for maximum lactation performance. There is a tendency however, to feed all dams alike even though they are nursing different numbers of pigs. Properly fed sows will lose weight during lactation; the amount of weight loss will be proportional to the weight of the sow at farrowing and the number of pigs being nursed. A general rule of thumb, to be applied with judgement, is to feed six pounds of feed plus one-half pound for each pig being nursed.

In times of relatively high feed cost, every aspect of management needs to be examined to achieve more units of production for each unit of cost input. Feed cost is a large proportion of total cost and many management practices affect feed efficiency. It thus presents relatively large opportunity to achieve lowered costs of production by making the management decisions that will improve feed efficiency.

NEW CONCERNS IN SWINE WASTE MANAGEMENT

J. Ronald Miner and Larry Boersma

Livestock waste management is not a new concern for swine producers. As soon as swine were confined, it was immediately obvious that manure handling was to be a major problem. Initially, techniques were required to separate manure from the animals to allow their economical production, and to allow the producer to tolerate the environs in which he was to work; thus, the first function of a swine waste management system was born. Some technique was necessary to separate the manure from the animal and to do this as quickly as possible. So long as open lot production had been the accepted practice, this was not a problem because the manure dried or was incorporated into the soil surface and created no further obvious problem. As soon as the animals were concentrated into a building to achieve the advantages of mechanized feed and water handling as well as protection from the environment, manure accumulated quickly and produced a building which was unsuitable for good animal performance.

Shortly thereafter, it also became obvious that swine manure was potentially a severe water pollutant, and if it were allowed to reach receiving streams, it created severe pollution problems. It was for this reason that in the 1960's extensive research programs were mounted to devise systems which accomplished the two above goals. During this decade the slotted floor was born, the flushing gutter was developed, and mechanical scraping systems were placed into operation. Great strides were made in devising systems which would mechanically remove manure from the swine building and process it for eventual application to crop land. With the availability of low cost chemical nutrients, the value of swine manure decreased and we began to speak of swine waste. Lagoons, oxidation ditches and other treatment devices gained popularity for their ability to decrease the strength of swine wastes, and therefore minimize the land area required for disposal. During the same decade, public interest in environmental quality increased, placing additional pressures on swine producers to provide systems that kept all manure from streams. This activity was culminated in 1972 by the passage of public law 92-500 by Congress which established the national goal of zero discharge into waters. With this legislation came the waste discharge permit system, with which many of you are familiar.

Current technology has evolved to such a point that facilities can be designed and operated to control water pollution that are compatible with efficient swine production. These systems have been implemented by using treatment devices, mechanical energy, and the swine producer's diligence to satisfy our needs for an abundant supply of high-quality, low-cost food without major environmental impact. More recently, we have been hearing the concept of non-point source pollution. Although currently few definitive regulations exist concerning the quality of runoff from land receiving manure applications and other waste sources which have no specific point of

J. R. Miner, Associate Professor, Department of Agricultural Engineering, Oregon State University; and Larry Boersma, Professor, Department of Soil Science.

entry, we may anticipate increased emphasis during the next five years. To accomplish these goals, a major research concern is to identify, measure, and control these pollution sources. They present special challenges to all of agriculture because of our association with the land and our influence over the quality of water which runs off this land.

Many of us will recall 1973 as the year in which we stood in line to purchase gasoline and were asked to reduce the lighting level and heating level in our homes to conserve energy. It was also the last year in which low cost chemical fertilizers were available to us in such an abundance as to encourage their extravagant use. The repercussions of our awakening to the concerns of energy consumption are just beginning to be felt. No matter what your attitude on recent increases in energy costs, it is evident that a new parameter has been introduced into our lives. System efficiency may very well be measured in the future by our ability to produce food at the least possible energy cost as well as the least possible labor cost, as has been the criterion in the past.

Animal manures have long been regarded as a rich source of plant nutrients. Abundant data exist documenting the value of swine manure for application to crop land. When alternate sources of plant nutrients were available, however, many studies can be quoted which concluded that the cost of applying plant nutrients to crop land by manure spreading was more costly than purchasing chemical fertilizers. From these studies grew our interest in swine waste disposal. The ideal system was conceived as one in which the manure dropped into a magic black box and was made to disappear with no residual whatsoever. The cost and energy consumption of this magic black box were of little concern in our overall efforts to devise an efficient swine production system.

As the cost of energy increases, the cost of chemically bound nitrogen and other fertilizers have also risen. As a result, manure may no longer be an animal waste, but may become an animal by-product.

In order for these transitions to take place, new systems are required which allow the value of animal manures to be utilized in more effective ways than has been possible in the past. No one is willing to give up the advances in swine production that have come to pass in the last fifteen years and return to the pitch fork, scoop shovel, manure spreader and tank wagon. Systems are needed which accomplish the goals of efficient waste handling and utilize the value of manure as an ultimate source of protein.

ONE ALTERNATIVE

One of the possible alternative schemes for managing swine manure to both control water pollution and to reclaim the nitrogen of manure is under investigation here at Oregon State University. In concept, the system combines waste products from two operations, namely, manure from swine production and waste heat from thermal electric generating plants in an attempt to gain a combination which has economic as well as societal advantages. The design of the waste management system is based on the concept of a confinement building in which the manure is quickly removed from the animal quarters. A two-foot wide gutter, two inches deep, placed at a 1% slope will be flushed periodically carrying manure in the gutter from the building. Previous work has indicated that pigs respond favorably to the flushing gutter concept and deposit the manure directly in the gutter. A full explanation of this phenomenon is not currently available, yet the moving water seems to attract the pigs to that area of the pen, and coupled with this is the innate characteristic of swine to maintain a clean living environment when possible. The water to be flushed in the system is effluent from the overall treatment system. The reclaiming of water from the manure water slurry which leaves the building is one major aspect of the overall system.

From the swine building the slurry will drop into a sump from which it is to be pumped into a solid-liquid separator. The solid-liquid separation device is one developed here at Oregon State University during the past three years, and consists of a tube mounted on a slight incline with the interior of the tube fitted with a helically-wound fin. A schematic of the solid-liquid separator is shown in Figure 1. In operation the swine manure slurry will be discharged into the solid-liquid separator about one-fourth the length from the upper end. The water then encounters a series of settling basins as it flows down the tube toward the lower end. Solids are deposited in the spaces between the fins by sedimentation. By slow rotation of the tube, those settled solids are worked toward the upper end. Once at the upper end, they drop from the solid-liquid separator.

The solid-liquid separator is mounted over an anaerobic digester so that the solids may be introduced into it without further handling difficulties. In this system, it is not necessary to produce an extremely dry solid material since the anaerobic digester requires a liquid system for best performance. The anaerobic digester will be agitated by the use of a recirculation pump and will also be heated to maintain a temperature of approximately 95^{o} F. In a full-scale operating system, the heating of the anaerobic digester would be done with waste heat derived from power plant cooling water. Thus, the coupling of livestock production and power plant wastewater discharges. In our system the anaerobic digestion will take place in two 1500 gallon concrete tanks similar to domestic septic tanks. By the use of the recirculating pump the two tanks will behave as a single chamber.

Effluent from the anaerobic digester will be combined with discharge from the solid-liquid separator and these two liquids used as input feed to a series of algae-growing basins. One of the important aspects of this research project will be to determine the growth rate of the algae under various operating conditions and under Willamette Valley climate. The algae basins will be operated between six and twelve inches deep and will have a retention time somewhere around two days. In our research unit, twelve individual algae growing basins will be used in order that we may operate them at a variety of temperatures and detention times.

Effluent from the algae-growing basins will be discharged into a storage tank from which accumulated liquid will be pumped to a centrifuge. The purpose of the centrifuge is to separate the water from the algal cells so that

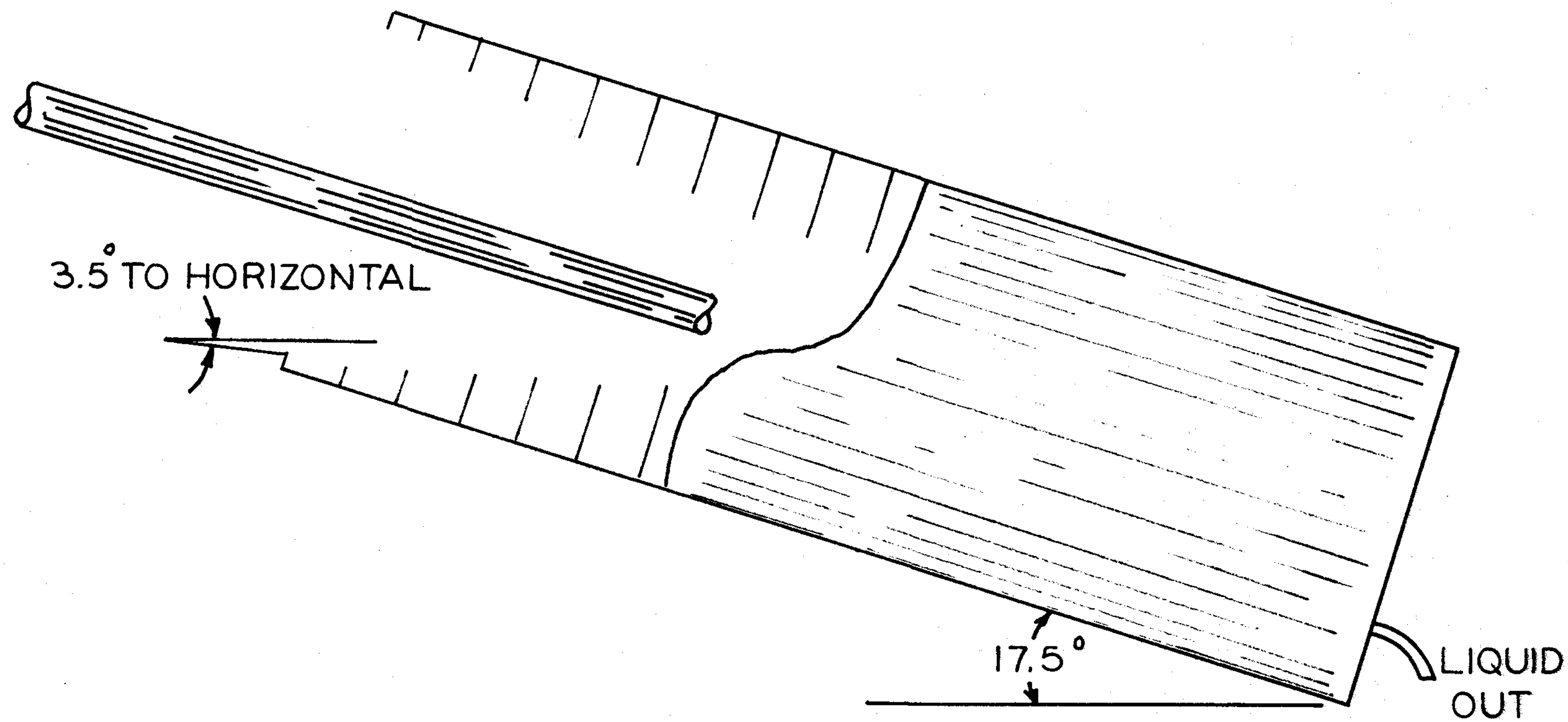


Figure 1. Schematic diagram showing the interior of rotating flighted cylinder solid-liquid separation device.

the water may be returned to the flush tanks for re-use in manure transport. The harvested algae will be evaluated as a potential swine feed ingredient in our process by chemical analysis and eventual feeding to experimental animals.

The flush tanks which are mounted at the upper end of the swine building gutter are fitted with automatic discharging siphons so that when the tanks are filled, the gutter will be automatically flushed. These tanks have been used previously in swine waste management systems and their operation has several advantages over other means of flushing gutters.

One other product of this system will be the gas produced by the anaerobic digester. In a full-scale operating system, this gas would be available for use as a fuel, either on the site or at some remote location. In our system, however, since we are interested in odor control, this gas will be discharged into a soil absorption field designed to deodorize the gas. This gas treatment system will be designed much like a tile drainage field for a septic tank system, except that instead of water percolating downward, digester gas will be allowed to percolate upward through the soil profile.

The overall system is shown schematically in Figure 2. Although more involved than most swine waste management systems currently in operation, this system consists principally of components already in use. The major questions we have are concerned with the ability to devise, design, and operate this series of components. A second series of questions exists concerning the ability to engineer an algae production system that is reliable and not subject to overgrowth by foreign organisms.

Algae were selected as the organism for nutrient recovery in this system because of the high productivity of rapidly growing algae cultures. Algae growth rates of up to one pound per hundred square feet daily are achievable under ideal conditions. We do not anticipate being able to maintain this growing rate under Oregon climatic conditions, however, we do anticipate achieving a rate of up to one half that. One aspect of this study will be to heat the experimental algae basins to various temperatures to determine the optimal operating temperature for a system of this type. The algae basins will be heated in a manner to simulate the system if it were operated in conjunction with a thermal power plant.

This study is designed to carry the current level of technology in swine waste management one step closer to an economically feasible closed-loop system which will meet the environmental quality demands of the future and simultaneously, be cognizant of our responsibility to operate with a minimal energy input. By avoiding the nitrogen losses which normally occur between the time of waste production and their incorporation into the soil and eventual conversion to plant material, it is hoped that this system will reduce the need for commercial fertilizer in the overall pork production process. The research system is designed to handle fifty hogs, which was selected as a system large enough to make problems obvious yet to be within the budget that could be accommodated on a research project. The design and the work currently under way represent the input of animal scientists, soil scientists, and agricultural engineers. This team approach will be necessary if we are to meet the demands of a sustained abundance of high-quality food at a price that people can afford, without adversely affecting the quality of air and water.

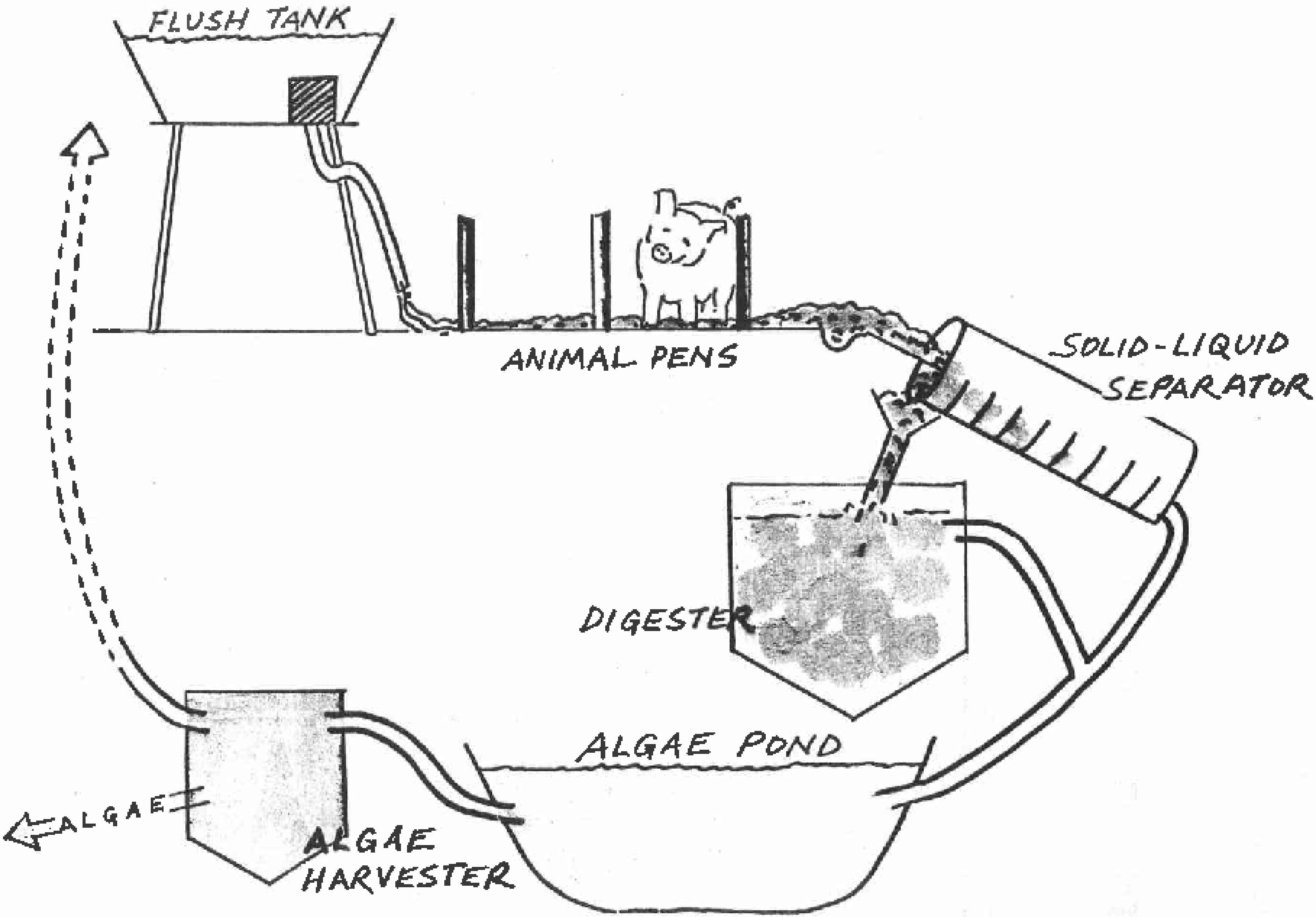


Figure 2. Overall concept of the O. S. U. experimental swine waste handling system