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An overview of production systems designed to prepare naïve replacement gilts for impending PRRSV challenge: A global perspective

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Summary

This paper reviews production systems for preparing gilts that are negative for porcine reproductive and respiratory syndrome virus (PRRSV) to be introduced into infected herds. We discuss four strategies, including: 1) two-stage development—isolation and acclimation centers, 2) Isowean™ introduction, 3) the transition center concept, and 4) the parity-one production herd. This paper does not attempt to rate the programs, nor provide results from scientific studies; rather, its primary purpose is to review a sampling of gilt development programs encountered throughout the world. Veterinarians are encouraged to assess the existing replacement stock strategies within their clients' herds, and to implement concepts derived from this paper to control PRRSV-related reproductive disease. Sample calculations for determining inventory and pig flow, as well as suggestions concerning the use of PRRSV vaccine, are provided.

Keywords: swine, PRRSV, production, gilts

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The importance of proper gilt development in maintaining breeding herd productivity is well established.[1] There have been several reports regarding the role of replacement gilts in attempts to control porcine reproductive and respiratory virus (PRRSV) in the breeding herd and weaned pig population.[2,3] Dee, et al.,[2] summarized the results of introducing PRRSV-negative replacement gilts into infected herds. In that study, we observed increases in conception failure, stillborns, preweaning mortality, and parturient sow mortality in a herd that directly introduced naïve gilts into an infected breeding herd. These effects were not detected in a similarly sized neighboring herd that used an internal replacement program to develop gilts. Production records indicated that the detrimental effects were limited to first- and second-parity females. PRRSV was isolated from affected females and their offspring and there was evidence that seroconversion occurred after infection. In contrast, testing in the neighboring herd indicated that pigs were infected early in life, giving them sufficient time to develop protective immunity.

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PRRSV can induce prolonged periods of viremia and shedding (up to 35–42 days).[4] In a field study, Dee, et al.,[3] found that it is essential to develop extended isolation periods to prevent viremic females from being introduced into infected breeding herds. An offsite gilt development facility was established, and infected replacement females were housed for a 4-month period before entering the recipient herd. This stopped PRRSV transmission in both the breeding herd and gilt pool populations, allowing control of the postweaning form of the disease through nursery depopulation.

To successfully control PRRSV, one must formulate gilt development strategies that prevent naïve or actively infected replacement stock from being directly introduced into a PRRSV-positive breeding herd. The trend in today's swine industry is to introduce larger groups of younger gilts into the breeding herd less frequently throughout the year.

The purpose of this paper is to provide an overview of four production techniques that have successfully prepared naïve replacement stock for introduction into PRRSV-infected herds. While there are obviously many protocols practiced in the industry today, I have chosen to discuss these four based on my experiences and confidence in them. The strategies discussed include the following:

- two-stage development: isolation and acclimation centers;
- Isowean™;
- the transition center model; and
- the parity-one (P1) production herd.

This paper does not attempt to specify which strategy is superior, nor does it provide scientific data derived from controlled or field studies. It does, however, provide sample calculations for determining inventory and pig flow, using a 1200-sow model herd as an example.

Two-stage development: Isolation and acclimation

The isolation and acclimation concept (IAC) has been summarized in detail in a previous publication, and readers are encouraged to refer to it for more complete information.[5] The IAC system comprises two stages—two separate facilities specifically designed to isolate from and then acclimate gilts to PRRSV prior to entry into infected herds.

The isolation stage facility is ideally located on a site away from the breeding herd that is devoid of swine. The isolation facility not only protects the existing system against the introduction of a new disease, it

also provides a designated period during which vaccination against PRRSV can occur prior to field virus challenge.

Vaccination against PRRSV is commonly administered when gilts arrive at the IAC, and at the end of the isolation period. Because in-vitro experiments indicate that the cellular immune system is capable of mounting an anamnestic response following re-exposure to field virus, I recommend two vaccinations.[6] Whether vaccine virus can provoke the anamnestic response is as of yet unknown. I recommend a minimum of 30 days between vaccinations because data indicate that < 30% of vaccinated breeding females may still be viremic 28 days post vaccination.[7] This strategy has been previously tested under field conditions and does appear to be effective for eliminating gilt-related subpopulations and controlling viral transmission within the breeding herd.[8,9]

The acclimation stage is usually located on the same site as the herd, and its goal is to expose replacement gilts to herd-specific isolates of PRRSV as well as other bacterial or viral agents. The period of time required in each stage is approximately 30 days; therefore, gilts must enter the isolation facility approximately 60 days prior to the desired age of mating.

Using the 1200-sow model, sample calculations involved in determining the number of gilts required on an annual basis are as follows:

1200 sow inventory×45% annual replacement rate =
540 gilts per year

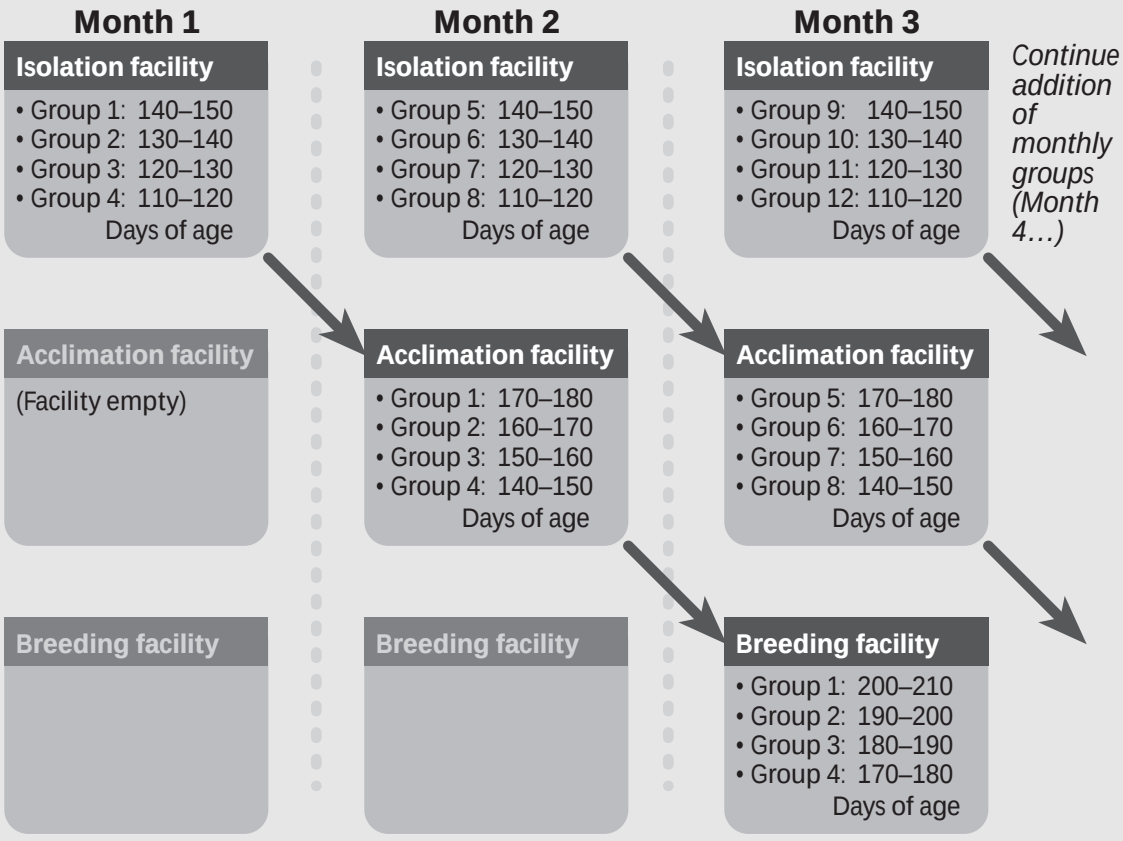
540 gilts ÷ 80% gilt conception rate ÷ 52 weeks =
12–13 gilts per week

4 weeks per month =
52 gilts required per monthly group

In order to comply with this longer development period, deliveries or replacement stock to the isolation facility are revised from a weekly to a monthly schedule (Figure 1). Within each monthly shipment are four groups of gilts, which vary in age based on a previously determined age of first mating. Each of the four groups represents 1 week of breeding females. The example provided in this paper is based on an age of first mating of 200–210 days. Therefore gilts enter the isolation facility varying in age from 110–150 days, and age groups are identified with differently colored ear tags.

Introducing replacement gilts prior to puberty enhances the induction of first estrus. Estrus can be initiated by boar contact, by transportation stress, and by administering exogenous hormones. One can synchro-

Figure 1



Monthly flow of replacement gilts between isolation, acclimation, and breeding facilities in the IAC model

Monthly groups of females enter each facility simultaneously and facilities are cleaned and disinfected after they are removed. Group size: 12–13 gilts / week; 48–52 gilts / group. Group size may fluctuate based on seasonal influence or culling practices.

nize estrus by administering commercially available preparations of pregnant mare serum and human chorionic gonadotropin (PG-600™, Intervet, Millsboro, Delaware) intramuscularly (IM) at 150–160 days of age, followed by an IM injection of prostaglandin $F_{2\alpha}$ (Lutalyse™, Pharmacia Upjohn, Kalamazoo, Michigan) 18 days later.[10] While exogenous hormonal treatments appear promising, they should be used as a supplemental means to induce estrus, and should not take the place of proper management techniques. Estrus detection should be attempted daily throughout the entire 60-day period, and cycling breeding females should be identified numerically and on the date estrus is detected. Each batch of gilts moves throughout both facilities using all-in–all-out (AIAO) pig flow, entering the breeding barn 60 days later.

The IAC concept can also be carried out using a single facility for isolation and acclimation by housing two monthly groups simultaneously, preferably offsite. With a single-stage IAC system, gilts are purchased at 2–4 months of age. This reduces the number of times purchased gilts are introduced to the breeding herd from 12 to six times a year, and requires that only one facility be constructed and managed. Obviously, the facility needs to be large enough to handle the increased number of breeding females and still be operated under AIAO principles. This strategy is widely practiced outside the United States, particularly in Europe and Asia, and is discussed in more detail in the "transition center model" section to follow.

Isowean™ introduction

This concept is based on receiving replacement stock as Isowean™ piglets, and is becoming widely adopted in the United States. The replacement stock may be introduced :

- on day 2 of life,
- at weaning,
- at 25 kg, or
- at 50 kg,

depending on the system design and the facilities available (Figure 2). An advantage of the Isowean™ system is that it allows replacement breeding females a greater period of time to become exposed, develop protective immunity, and eliminate viremia and shedding. An Isowean™ gilt may have up to 5–6 months to develop, in contrast to the IAC system, which only allows 60 days for isolation and acclimation.

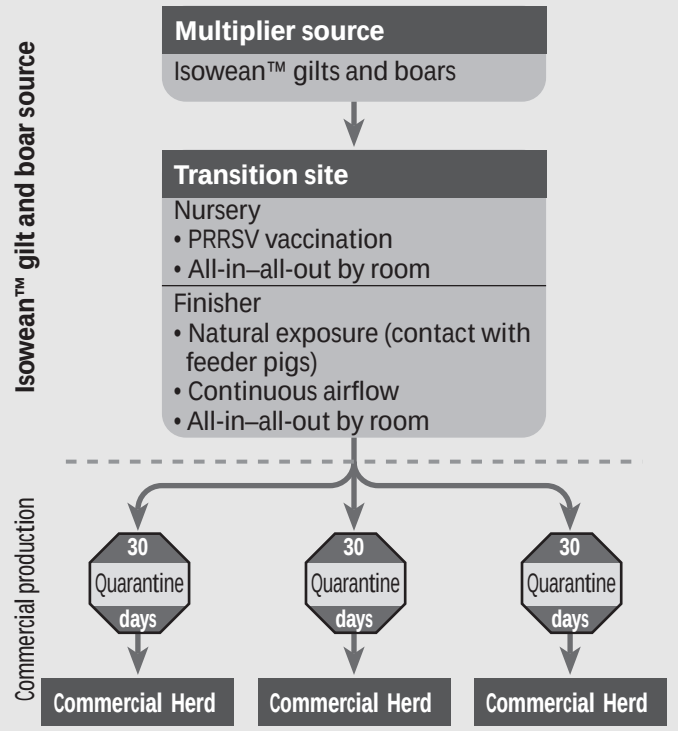
Using the 1200-sow model, the number of select gilts produced per year in an Isowean™ system can be calculated as follows:

1200 sows × 9 pigs weaned per litter × 2.35 litters per sow per year = 25,380 pigs per year

25,380 pigs × 50% female × 4% wean-to-market mortality × 70% selection = 8880 selects

In this example, the multiplier herd could provide approximately 160 select Isowean™ gilts per week, meeting the needs of a 15,000 commercial sows, based on annual replacement rates of 45% and gilt conception rate of 80%.

Figure 2



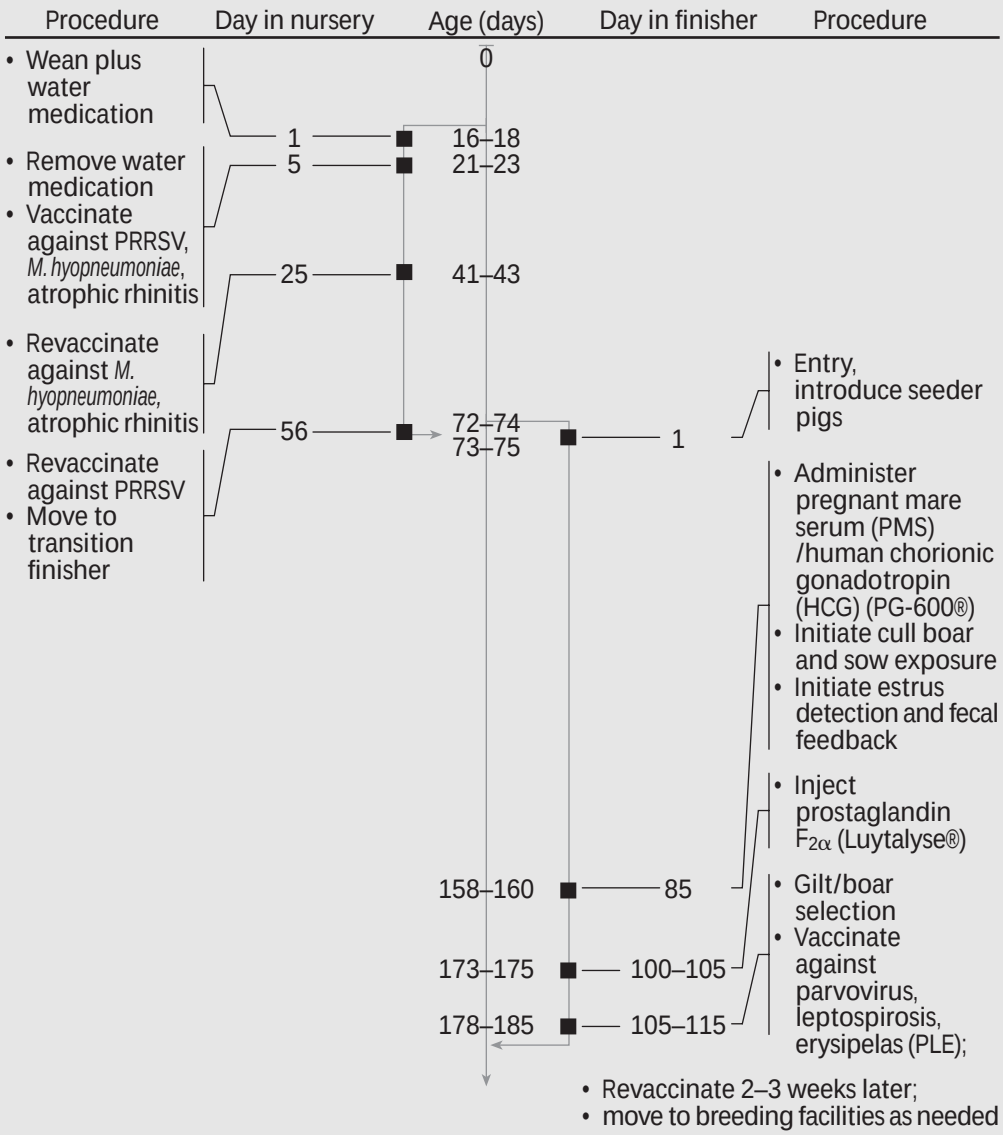
Isowean™ introduction program

Isowean™ piglets are frequently weaned at 16–18 days of age into the transition nursery, which provides sufficient time for active immunization against PRRSV and other existing diseases (Figure 3). In this example, PRRSV vaccination is administered shortly after arrival in the nursery and upon transfer to the finisher. In the nursery, rooms are managed according to AIAO pig flow with 2 weeks of production per nursery room. Each building contains four rooms, providing space for approximately 8 weeks of production (1200 pig capacity), and 0.27 m^2 (3 sq feet) of space is provided per pig.

The finisher consists of AIAO rooms within a continuous air space to enhance natural exposure to the designated pathogens. In this case, the capacity of the finisher is 1200 breeding females in four rooms, with each room sized to house a nursery room's production. Each room contains 12 pens with 25 pigs per pen at 0.73 m^2 (8 sq feet) per pig with open gating to enhance pig contact. Upon arrival to the finisher, pigs in each pen are mixed with one to two "seeder pigs" from existing commercial nurseries to enhance exposure to herd-specific pathogens. Seeder pigs are typically nursery- or finishing-age pigs that originate from infected populations and are selected based on diagnostic data, including serologic profiling and virus isolation. The first estrus is induced with cull boars (Figure 3). Females are introduced at a predetermined time. Fecal material from cull pigs is spread throughout the pens to enhance exposure to coliforms and parvovirus.

In this example, at approximately 180 days of age, gilts are selected, ear tagged, and revaccinated against PRRSV. The initial vaccination for protection against parvovirus, *Leptospirosis* spp., and *Erysipelothrix*

Figure 3



Site-specific plan for an Isowean™ introduction program

rhusiopathiae is also given at this time, and repeated 2–3 weeks later. After selection, gilts are moved to quarantine units on the site of the commercial herd for a 30-day period in accordance with standard biosecurity practice to allow for a "recovery period" after the acclimation program is completed.

A modification of the Isowean™ concept is to introduce replacement gilts to recipient herds as suckling piglets. Based on the previously described production parameters, a 500-sow multiplier unit can provide sufficient numbers of replacement gilts for up to five to six 1200-sow herds, based on the requirements of 20 gilt piglets to a commercial unit each week:

500 sows × 10.5 pigs born per litter ×
2.35 litters per sow per year = 12,337 pigs

12,337 pigs × 50% female ÷ 52 weeks =
120 gilts per week

In this program, it is critical to maximize transfer of immunity from the sow to the piglet. Sows are vaccinated prior to farrowing using strategic vaccination protocols to immunize against specific pathogens, and techniques such as cross fostering or split suckling are used to maximize colostral intake during the first day of life. When gilts are removed at 2 days of age, the remaining piglets are distributed throughout the lactating sow population. A target of six to seven piglets per sow is desirable. If there are not enough piglets, certain sows may need to be weaned early and allowed to return to estrus. Once they arrive in the commercial herd, gilts are fostered onto sows with an excellent lactation history, forming designated gilt litters. These replacements are then raised in the herd and selected to be included into the breeding herd at the proper age.

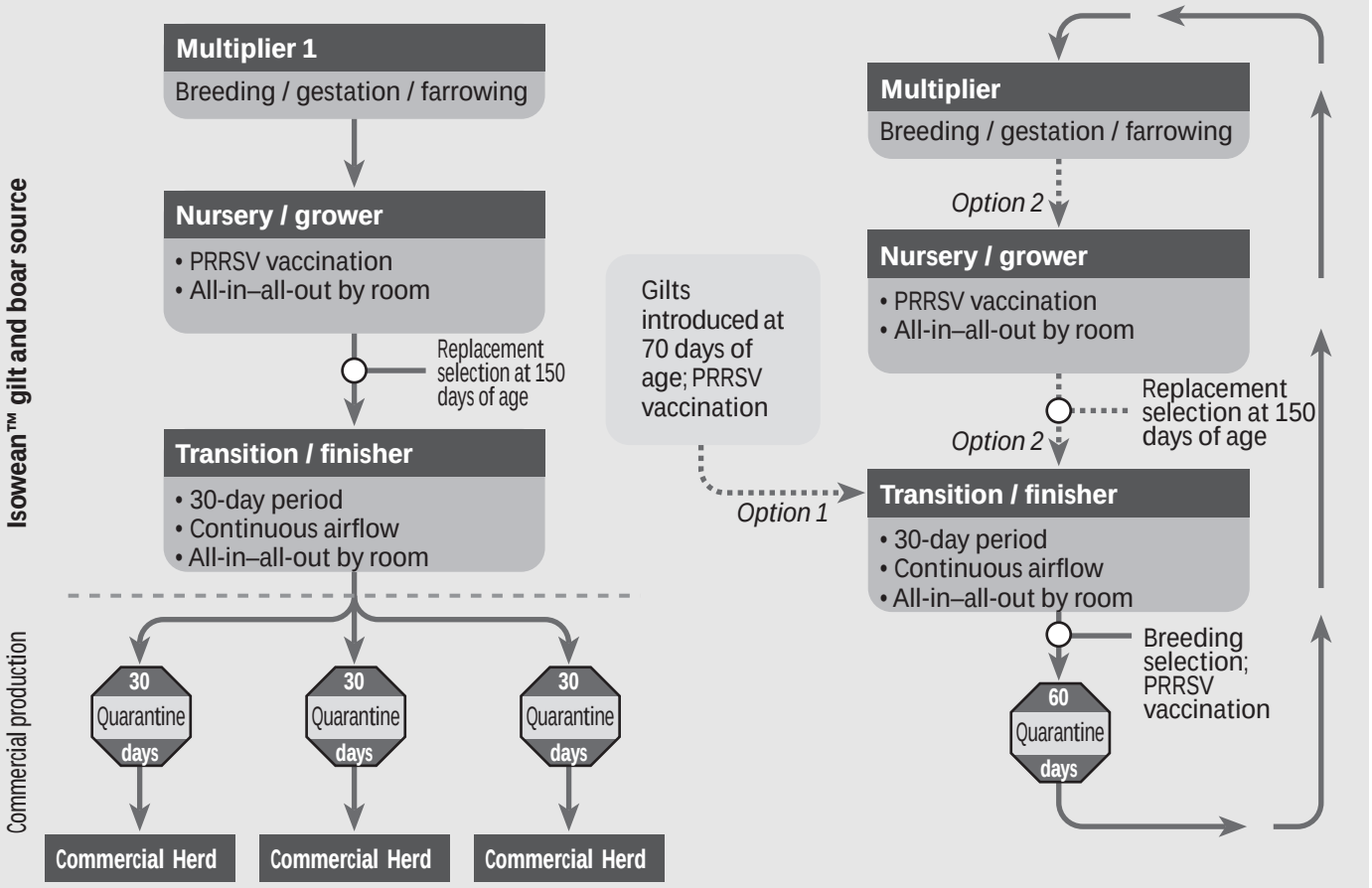
The transition center model

This model is similar to that described for the Isowean™ program, except that breeding females begin the development program later in life, during the finishing phase (Figure 4a, left). Before they enter the breeding herd, gilts are vaccinated against PRRSV as well as against other designated pathogens, e.g., *Mycoplasma hyopneumoniae*. A finishing facility serves as the transition center and operates under AIAO-by-room pig flow within a continuous airspace. Gilts are acclimated during this phase as previously described, and reside in this facility for 30 days. After acclimation, gilts enter a quarantine for 30 days before they are introduced into the commercial production herd. If strict quarantines are maintained on all commercial sites, multiple-sourced gilts from herds of equal health status could enter the transition center; however, strict rules of quarantine and health monitoring would need to be practiced in these cases.

In a single-site commercial system, the existing finishing facility can successfully serve as the transition center (Figure 4a, right), after 10-week-old gilts are purchased and introduced into the herd from an outside source. This "onsite acclimation program" has been used extensively in the industry because it allows a 2- to 3-month period for natural exposure to occur. In the example provided, gilts reside in the finisher until 150 days of age and are selected and moved to quarantine units for a 60-day period before they enter the breeding herd. This program is popular in countries that do not have commercially available PRRSV vaccines or sufficient land mass for multiple sites, and that operate using continuous-flow finishing facilities with evidence of active virus transmission. If PRRSV vaccines are employed, they should be administered prior to challenge.

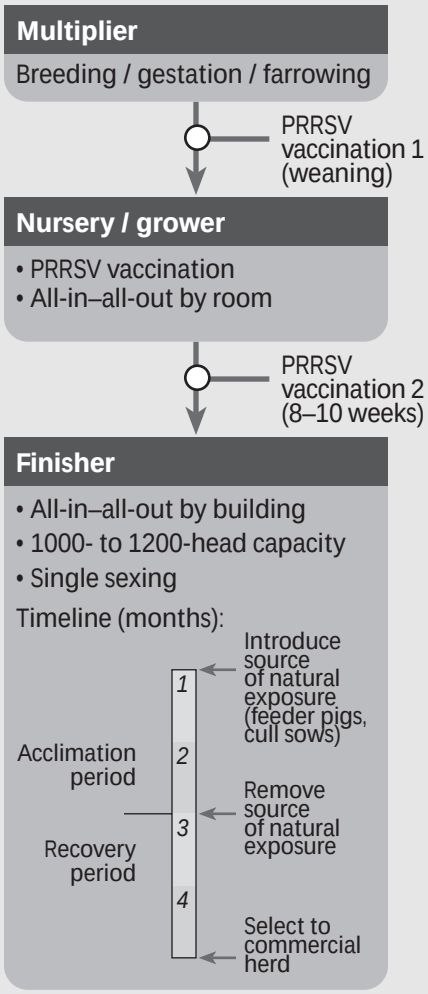
The quarantine bypass program is another modification of the transition center model (Figure 4b). This strategy is very applicable in production systems in the United States that are already established and do not have an existing quarantine plan. In large production systems with internal multiplication, it is often possible to populate 1000- to 1200-head finishing facilities on a weekly basis with either barrows or gilts. To develop protected gilts that are not actively infected, AIAO-by-building pig flow is extremely effective. The initial PRRSV vaccination is given when gilts enter the nursery or sometime during the nursery phase, and are revaccinated when they enter the finishing facility. Immediately after they enter, acclimation is initiated over a designated

Figure 4a



Transition finishing center models: offsite (left) and onsite (right)

Figure 4b



Quarantine bypass program

period of time, i.e., 1–2 months. In this case, the source of natural exposure typically consists of sows recently experiencing PRRSV-induced reproductive failure, and infected seeder pigs from the commercial units within the system.

Once the acclimation period is complete, the source of natural exposure is removed from the facility and the population is allowed to "recover" over a 1- to 2-month period before replacements are selected and introduced into the breeding herd. By using AIAO-by-building pig flow, along with designated periods of acclimation and recovery, it is possible to "bypass" a quarantine facility in developing replacement gilts.

The parity-one (P1) production herd

Experience with parity-one (P1) production herds in the United States is somewhat limited at this time; however, preliminary observations suggest that it could be potentially advantageous for large systems (≥20,000 sows). The goal of the P1 production herd is to raise, breed, gestate, farrow, and wean mature P1 females into commercial herds, thereby removing the gilt pool from the commercial production system. The benefits of this strategy include a specialized labor force to manage gilts, enhanced opportunity to implement proper feeding programs to minimize excessive weight gain and subsequent musculoskeletal problems, as well as a prolonged period of time in which to acclimate gilts to PRRSV. Since the multiplier consists entirely of gilts, the P1 center can also provide 6-month-old replacement females and/or bred gilts to production units within the system to maintain weekly breeding and farrowing targets. During each weekly weaning, females from the P1 production unit are distributed as needed to the commercial herds within the system. Offspring from P1 litters can be raised onsite, moved to offsite facilities within the system, or sold as Isowean™ pigs.

Figure 5a describes the pigflow of a P1 production unit that consists of an internal multiplication system. In this example, a 500-sow F1 breeding herd provides the necessary number of F2 replacement gilts for the 1200-sow inventory:

500 sows × 9 pigs weaned per litter ×
2.35 litters per sow per year = 10,575 pigs per year

10,575 pigs × 50% gilts × 4% mortality ×
70% selection = 5075 gilts

This provides approximately 70 females per week, meeting the weekly breeding requirements of the 1200-sow P1 production unit:

1200 sows × 2.35 litters per sow per year ÷ 52 =
54 farrowings per week

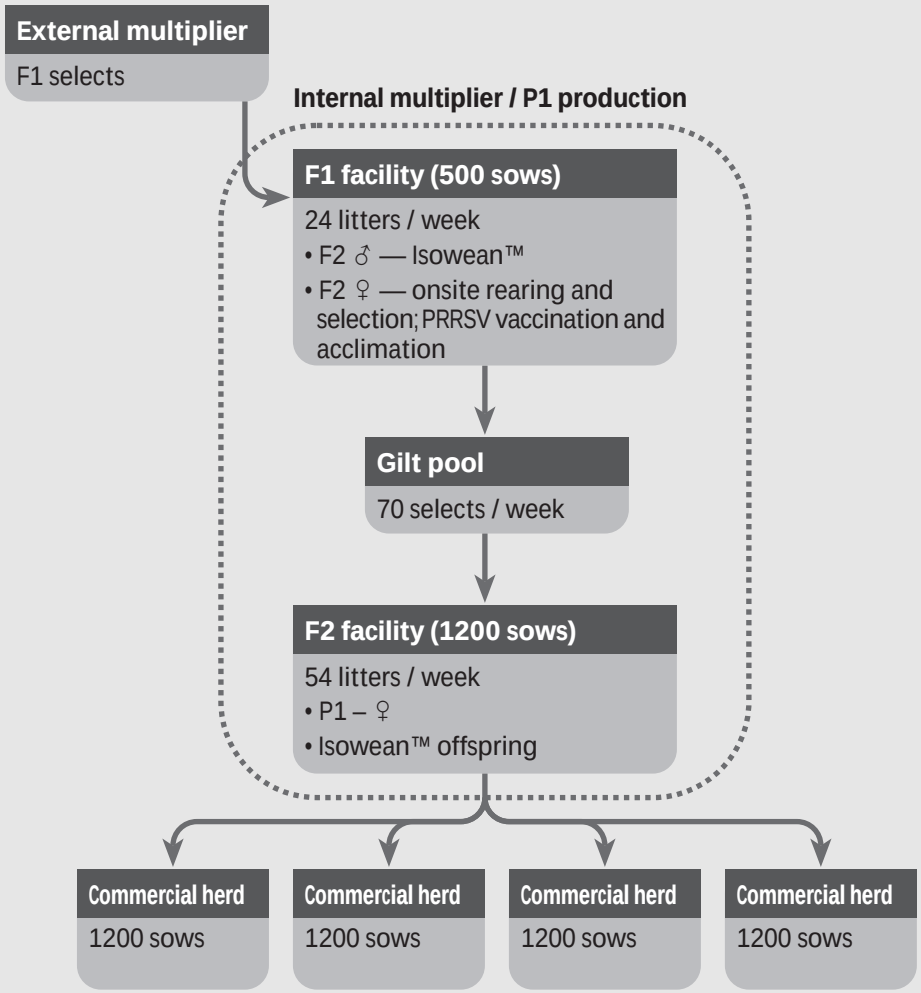
54 farrowings per week ÷ 80% gilt conception =
68 females required per week

Based on a 45% annual replacement rate and an 80% gilt conception rate, the 1200-sow commercial units within the system require approximately 12–13 gilts each week. Therefore one 1200-sow P1 production unit can supply approximately four comparably sized commercial units. In the example shown in Figure 5a, males are sold as weaned pigs while gilts are raised onsite until they are selected for the breeding herd. PRRSV vaccination can be given at weaning age and selection.

It is also possible to introduce replacement females from an outside source, e.g., Isowean™ introduction, using any one of the previously described programs, bypassing the need for an internal multiplier (Figure 5b).

One of the disadvantages of systems such as the P1 production herd is that infectious agents can be transmitted to commercial herds, due to the fact that there are no quarantine facilities between the P1 production unit and the recipient herds. Therefore, it is critical to properly match health status between all herds and practice sound biosecurity principles throughout the system. As of this writing, it has been my experience that such problems can be prevented and that weaned P1 females respond very well to the transport stress between sites, resulting in wean-to-estrus intervals that are within normal limits (4–6 days). Another question yet unanswered is whether it is economically feasible

Figure 5a



P1 production facility with internal multiplier

to have a P1 production herd within an existing system.

Discussion

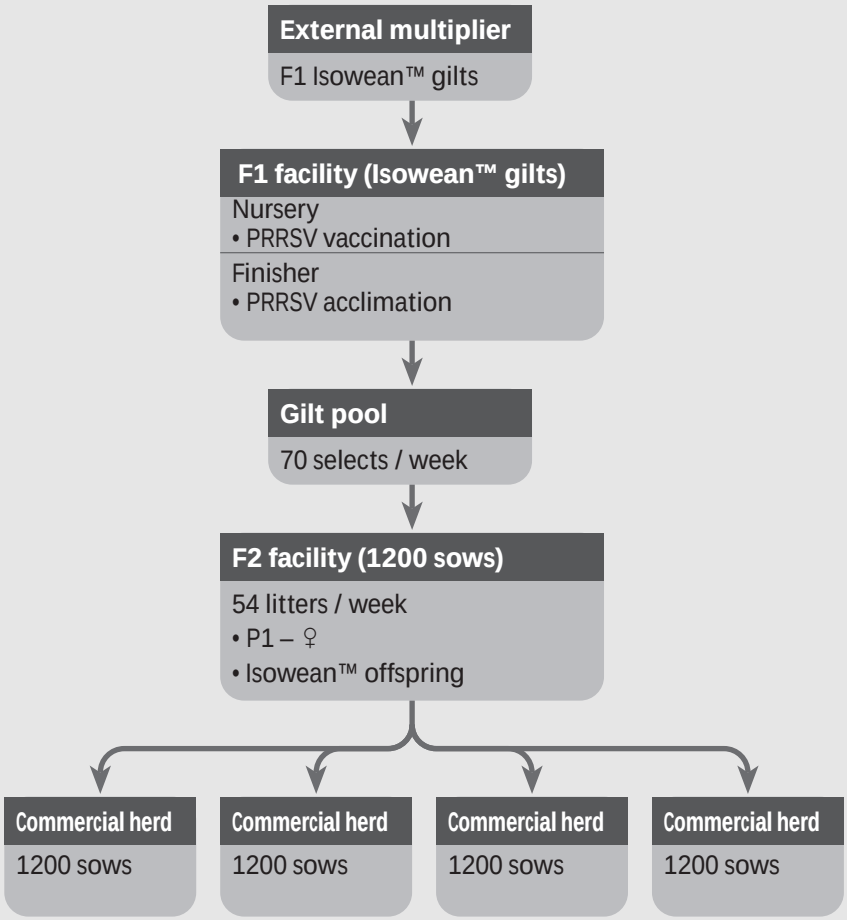
Although some of these methods may seem "futuristic," the concepts are sound and are being implemented throughout the international swine industry. Therefore, it is important that practitioners critically evaluate existing gilt development programs within their clients' herds to determine whether any of these strategies can be applied to enhance PRRSV control.

Replacement boars should be handled in a similar manner. At this time, all systems appear to be functioning extremely well; therefore, the choice of the development strategy depends on the size of the herd, the status of existing facilities, future expansion plans, availability of commercial PRRSV vaccines, and any potential economic constraints. Decision tree analysis (Figure 6) can be used to determine the optimal strategy for any given herd.

Based on my experiences over the last 4 years, I speculate that the most advantageous system would consist of purchasing PRRS-negative Isowean™ pigs, a program of vaccination in the nursery stage, and designated periods of acclimation and recovery during the finishing phase, followed by a 30-day quarantine before the replacements are introduced into the breeding herd (Figure 6). If the finisher pig flow is AIAO by building, the quarantine bypass concept appears to work very well, and the risk of introducing actively infected gilts is low.[11] Due to the wide variation in virulence of PRRSV isolates, I believe that the purchase of negative stock would allow the practitioner to design a strategy to properly expose breeding females to the herd-specific viral isolate. Furthermore, since the presence of antibodies to PRRSV does not correlate at all with protective immunity, the old adage of "buying positive equals protected" does not apply in this case.

Obviously, there are disadvantages with all of these systems. The extra cost of feed, facilities, and labor will be present in all systems that introduce younger stock. The cost of constructing an isolation facility that is sized for a 50–60 gilt inventory in the midwestern United States

Figure 5b



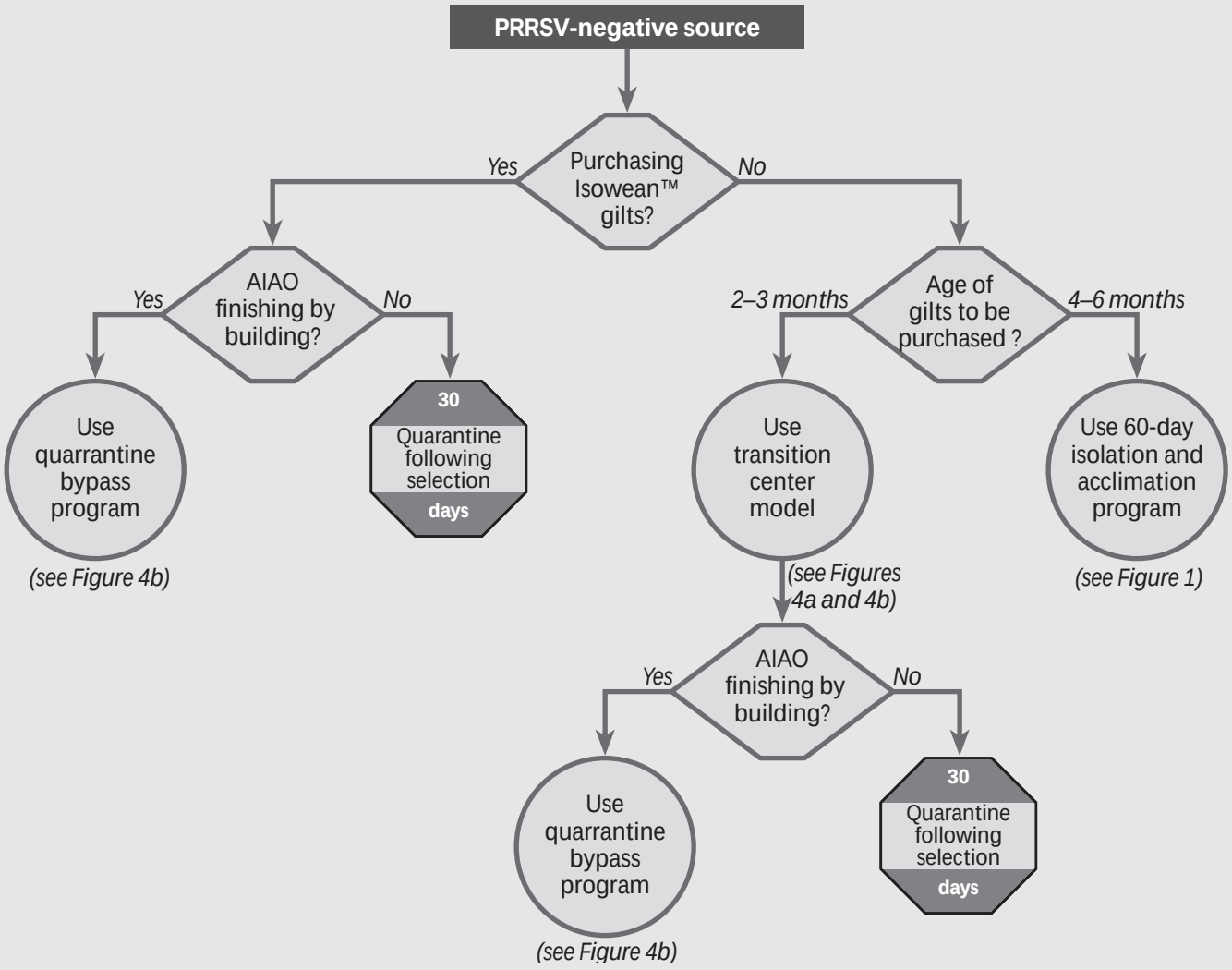
P1 production facility using Isowean™ females introduced from an external source

may range from $20,000 to $24,000; however, if existing finishing facilities can be purchased or rented, the cost is usually much less. Another obstacle to overcome is the potential inability to meet breeding targets due to the difficulty in synchronizing the estrus cycle of the gilt. Fortunately, the ability to work with prepubertal gilts enhances estrus control. Nonetheless, it is important to calculate a sufficient number of replacements, using realistic estimates of gilt farrowing roles through the use of computerized production record systems. Gilt pool inventory is frequently calculated according to projected gilt farrowing rates of 70% in the summer months, and 80% during the remainder of the year.[11] Therefore, producers account for an increase in gilt inventory of 30% during spring, summer, and fall and up to 50% during periods of extreme heat (27–30°C, 81–86 °F) to ensure that targets are met. Again, as larger numbers of breeding females are purchased or raised on herd, there will be extra cost.

Finally, it is important that the practitioner monitor the success of these programs on a regular basis. Prior to being selected for the breeding herd, a randomly selected representative sample of the gilt population should be tested to assess seroprevalence and to measure titer magnitude and variation. The accuracy of the testing can be enhanced by collecting samples from the onset of the acclimation program and retesting specific breeding females once the program has been completed. If a large percentage (10%–20%) of the breeding females are seronegative, it may indicate that there are improperly exposed breeding females within the population, and it may be necessary to revaccinate before they enter the breeding herd. Based on published data,[9] a combination of ELISA and serum-neutralizing (SN) antibody tests provides the greatest degree of accuracy when attempting to identify noninfected, acutely infected, or chronically infected breeding females. Also, in conjunction with diagnostic data, production records should regularly be assessed by parity in order to follow the progress of the replacement breeding females during their initial periods of pregnancy and lactation.

While there is no ideal strategy for all production systems, the improved understanding of the relationship between replacement gilts and the control of PRRSV-related disease problems in the breeding herd underscores the importance of the replacement population. The challenge to the industry will be not only to improve these systems, but to apply their principles to the control of new infectious disease problems that will undoubtedly arise in the future.

Figure 6



Decision tree to determine optimal strategy for any given herd

Implications

- Properly managing replacement breeding stock is critical to successfully controlling PRRS.
- Introducing naïve gilts or actively infected animals will perpetuate PRRSV circulation in the breeding herd.
- Naïve gilts need to be properly developed before they enter an infected herd.
- In the United States, the trend is toward introducing larger groups of younger animals less frequently throughout the year.

References

1. Dial GD, Duang C, King V, Rademacher C. The influence of the gilt pool on weaned pig output. *Proc AD Leman Conf*. 1996; 39–41.

2. Dee SA, Joo HS. Clinical investigation of recurrent reproductive failure with PRRSV in a swine herd. *JAVMA*. 1994; 204:1017–1018.

3. Dee SA, Joo HS, Pijoan C. Controlling the spread of PRRSV in the breeding herd through management of the gilt pool. *SHAP*. 1994; 3:64–69.

4. Yoon IJ, Joo HS, Christianson WT, et al. Persistent and contact infection in nursery pigs experimentally infected with PRRS virus. *SHAP*. 1993; 1(4):5–8.

5. Dee SA. Gilt development and PRRS: A model program for the US swine industry. *Comp Cont Ed.* (accepted for publication).

6. Bautista EM, Meulenberg JMM, Choi CS, et al. PRRSV-specific T cell responses in infected and vaccinated pigs. *Proc 14th IPVS*, 1996; 63.

7. Polson DD. RespPRRS®: A vaccine review. In *PRRS/RespPRRS Reference Guide*. 1994. NOBL Laboratories. 7 8.

8. Dee SA, Joo HS, Park BK, et al. Attempted elimination of PRRSV from a seedstock herd using breeding herd vaccination and nursery depopulation. *Vet Rec*. (accepted for publication).

9. Dee SA, Joo HS, Henry S, et al. Detecting breeding herd subpopulations after PRRSV infection in large breeding herds using multiple serologic tests. *SHAP*. 1996; 4 (4):181–184.

10. Britt JH. Manipulation of the porcine estrous cycle. *Proc AASP, ACT and ST Swine Repro Symp*. 1996; 83–86.

11. Dee SA, Personal experience. 1994–1997.