Supplementary Table S1. Questionnaire used for data collection in the sustainability assessment

Questions used for collecting information from breeding organisations (BO)

*1. Basic facts about the population and breeding structure*

1.1 Sire line: purebred/cross/synthetic

1.2 Dam line: purebred/cross/synthetic

1.3 Structure: Number of nucleus herds, multiplying herds, production herds

1.4 Population size: Approx. number of purebred animals in different breeds in nucleus herds and in multiplying herds

*2. How is the market and product defined?*

2.1 Which are, according to BO, the main characteristics of this production system (e.g. conventional – intensive, indoor)?

2.2 What does BO expect for the future of this system? Trends in political, economic and social attitudes, including social conformity (the degree to which that production system meets the requirements and expectations of the society) of production

2.3 Has BO analysed the need for marketing?

2.4 How is marketing performed?

2.5 How does BO define sustainable breeding?

2.6 Does BO belong to a quality assurance scheme? What scheme?

2.7 Does BO recommend/force the breeders to belong to a quality assurance scheme? What scheme?

*3. Characteristics of the breed (if a local breed is used)*

3.1 Does BO consider the used breed as an endangered breed?

3.2 Degree of endangerment (e.g. critical, endangered, not at risk)?

3.3 Does BO participate in a conservation programme?

3.4 Is this breed genetically unique? How does BO know that?

3.5 Does this breed have unique traits, according to BO?

3.6 Are the unique traits of economic importance?

3.7 Is this breed especially adapted to the specific environment? To the specific production system?

3.8 Does this breed, according to BO, have cultural values? Historical values? Social values?

*4. How is the breeding goal defined?*

4.1 How does BO describe the breeding goal for the different breeds (e.g. selected for meat quality)?

4.2 Which traits are included in the breeding goal?

4.3 Which of the goal traits are important for the income or the costs of production (in a short term economic perspective)? To what degree (very important, important, not so important, not important at all)?

4.4 Any goal traits related to animal health? Animal welfare? Reproduction without hormonal treatments? Product quality? Consumer health? Environmental impact?

4.5 Breeding goals are not constant. How often and why does BO evaluate and change the breeding goal?

4.6 Are the farmers involved in the process of developing the breeding goal?

4.7 How does BO document the development of the breeding goal?

4.8.1 Has BO verified the acceptance of the breeding goal by producers of piglets? Producers of pigs for slaughter? Breeders?

4.8.2 Has BO verified the acceptance of the breeding goal by slaughter plants? Industry?

4.9 Which of the goal traits have an economic market value? Which traits have no market value?

*5. Which traits are recorded and which are included in the genetic evaluation?*

5.1 Describe the recording of selection traits. What? How? Where? When?

5.2 Describe the recording of traits recorded to detect undesirable correlated changes (e.g. in animal health or welfare or product quality). What? How? Where? When?

5.3 Are management and recording routines described for the farmers and technical assistants in a ‘manual’ or ‘rule book’?

5.4 Which selection traits are handled as quantitative traits in the breeding programme?

5.5 Which selection traits are qualitative traits, governed by a known single gene?

5.6 Is marker assisted selection used in the breeding programme? For which traits?

5.7 Is genomic selection (also called genome wide selection) used in the breeding programme?

5.8.1 Have BO verified the acceptance of the pig handling routines, recording methods and reproduction techniques by producers of piglets? Producers of pigs for slaughter?

5.8.2 Have BO verified the acceptance of the pig handling routines, recording methods and reproduction techniques by breeders?

5.8.3 Have BO verified the acceptance of the pig handling routines, recording methods and reproduction techniques by slaughter plants? Industry?

5.9 How are the ‘economic weights’ decided for traits with an economic market value?

5.10 How are the ‘economic weights’ decided for traits without a market value?

*6. How is sensitivity to external factors addressed?*

6.1 Has BO experienced large fluctuations in the market so far?

6.2 Does BO see any trends in the market?

6.3 Does BO have a back-up to account for unexpected situations such as diseases and accidents (e.g. cry-conserved germplasm, dispersed elite populations)?

6.4 Is food safety an important issue for BO in the studied system? In what way?

6.5 Is BO concerned with genotype-environment interactions for the studied system?

6.6 Has BO verified the acceptance of the breeding goal by citizens? Consumers? (All citizens are not consumers)

6.7 Has BO verified the acceptance of the pig handling routines, recording methods and reproduction techniques by citizens? Consumers? (All citizens are not consumers)

6.8 How does BO handle public relations?

6.9 Does BO have a policy document?

6.10 What does BO include in its policy document for transparency (e.g. description of the breeding scheme used)?

6.11 Does BO have cooperation with another breeding organisation? In what way?

6.12 Is BO dependent on other breeding organisations? In what way?

6.13 Has BO subscribed to the Code of Good Practice (Code EFABAR)? Planning to do so? Why or why not?

*7. Which resources are available?*

7.1 Who is the owner of BO?

7.2 How many people work with the breeding programme at the organisation (not including nucleus farmers)? Their ‘average’ education at different positions?

7.3 Do the geneticists participate in scientific conferences?

7.4 Are the geneticists co-authors of scientific articles?

7.5.1 Does BO have a research & development unit?

7.5.2 Does BO have an IT unit? Technical facilities (e.g. lab facilities)?

7.6 Does BO have cooperation with a research institute? A university?

7.7 Does BO have an education programme for farmers? For technical assistants? For staff at the office?

*8. How is a sufficiently large effective population size secured?*

8.1 What is BO’s goal concerning inbreeding? Has BO defined a maximum % inbreeding increase per generation?

8.2 How is inbreeding increase monitored?

8.3 How is a too large inbreeding increase avoided?

8.4 Do the nucleus farmers decide which animals to mate or is that decided by BO?

8.5 Does BO use a programme for maximising selection response with a minimum increase in inbreeding (e.g. EVA or GenCont)?

8.6 Is pedigree completeness quantified?

8.7 Are new animals (or semen) imported into the nucleus? When, why and from where?

8.8 Does BO feel responsible for the conservation of a local breed?

*9. How are the expected effects of selection predicted?*

9.1 How are genetic trends for the breeding goal traits predicted? (quantitative traits and qualitative/single gene traits)

9.2 Are genetic trends predicted for potentially important traits that are not included in the breeding goal?

9.3 Is the genetic impact of changes in recording and handling routines predicted?

*10. How is genetic progress monitored and evaluated?*

10.1 How are genetic trends for the breeding goal traits estimated and presented? (quantitative traits and qualitative/single gene traits)

10.2 Are genetic trends estimated and presented for potentially important traits that are not included in the breeding goal?

10.3 Is the genetic impact of changes in recording and handling routines estimated?

*11. Which milestones have been defined?*

11.1 Has BO stated specific goals for the quantitative traits (e.g. 5% lower piglet mortality in the production herds within 10 years)? For the qualitative traits (e.g. >70% pigs in year 2012 should have a certain allele giving resistance to E coli)?

11.2 Has BO stated specific goals for their market share?

11.3 Has BO stated specific goals for their fulfilment of the customers’/members’ demands? The consumers’ demands?

*12. How is the profitability of the breeding scheme evaluated?*

12.1 Does BO estimate the economic costs of their breeding work, e.g. per produced pig or per unit genetic progress? How?

12.2 Are these costs presented? To whom?

12.3 Does BO estimate the economic income of their breeding work, e.g. per produced pig or per unit genetic progress? How?

12.4 Is this income presented? To whom?

12.5 Does BO estimate the economic gain of their breeding work, e.g. per produced pig or per unit genetic progress?

12.6 Is this gain presented? To whom?

*13. Main threats*

13.1 What is, according to BO, the main future threat to the breeding programme? To the studied production system?

Questions used for collecting information from farmers. Separate answers were given for gilts/sows and boars/semen. It was allowed to answer ‘Don’t know’.

h1. Number of breeding animals in the herd?

h2. Are they purebred animals?

h3. What is the name of the pure breed, cross or synthetic breed?

h4. What are the main breeding companies used for replacement of gilts and boars and for semen?

h5. Which reproduction techniques are used? Artificial insemination or natural service? (If both, give the approximate proportion of natural matings)

h6. When buying gilts, boars and semen, what are you looking for (growth rate, carcass quality, meat quality, litter size, fertility, maternal traits, animal health, conformation, feed efficiency, robustness, conservation of breed)?

h7. Do you know the identity (pedigree) of the animals and semen you buy?

h8. What are the average yearly entries of gilts and boars for replacements? (Number of animals)

h9. How large part of these gilts and boars are born in the herd? (%)

h10. Which traits are recorded at the farm (growth rate, carcass quality, meat quality, litter size, fertility, maternal traits, animal health, conformation, feed efficiency, robustness, conservation of breed)?

h11. Do you record the identity (pedigree) of animals born at the farm?

h12. What is the maximum number of litters per sow and boar?

h13. What is the max. level of coancestry admitted for mating in your herd? (%)

h14. Are you interested in genetics and pig breeding (not at all, a little, rather much, very much)?

h15. Are you interested in genetic diversity and conservation of genetic resources (not at all, a little, rather much, very much)?

Supplementary Table S2. Presentation of which question that was included in which dimension and indicator in the sustainability assessment

|  |  |
| --- | --- |
| Dimensions and indicators  | Included questions from the questionnaire  |
| *Breeding goal and market* |  |  |  |  |  |  |  |  |
| Market - breeding goal | 4.1–4 | 4.9 | 6.5 |  |  |  |  |  |
| Definition sustainable | 2.5 |  |  |  |  |  |  |  |
| External factors | 2.4 | 2.6–7 | 6.1 | 6.3 |  |  |  |  |
| System’s demand | 2.1 | 4.2 |  |  |  |  |  |  |
| Farmers’ demand | h6 | 4.2 | 4.6 | 4.8.1 |  |  |  |  |
| Foresight of threats | 2.2 | 2.3 | 6.2 | 13 |  |  |  |  |
| *Recording and selection* |  |  |  |  |  |  |  |  |
| Recorded traits | 4.5 | 5.1–2 |  |  |  |  |  |  |
| Methods for recording | 5.3 | 5.8.2 | 9.3 |  |  |  |  |  |
| Estimated genetic change | 9.1–2 | 10 |  |  |  |  |  |  |
| Profitability | 5.9–10 | 12.1 | 12.3 | 12.5 |  |  |  |  |
| *Genetic variation* |  |  |  |  |  |  |  |  |
| Effective population size | 1 |  |  |  |  |  |  |  |
| Limit inbreeding | 8.1–4 | 8.6–7 |  |  |  |  |  |  |
| Use of OCS | 8.5 |  |  |  |  |  |  |  |
| Organisation’s interest | 3.3 | 8.8 |  |  |  |  |  |  |
| Farmers’ interest | h15 |  |  |  |  |  |  |  |
| Uniqueness of breed | 3.1–2 | 3.4–8 |  |  |  |  |  |  |
| *Management of breeding org.* |  |  |  |  |  |  |  |  |
| Economic, technical resources | 6.12 | 7.1 | 7.5.2 |  |  |  |  |  |
| Choice of methods | 5.4–7 |  |  |  |  |  |  |  |
| Human resources | h14 | 6.11 | 7.2–4 | 7.5.1 | 7.6 | 7.7 |  |  |
| Communication, transparency | 4.7 | 4.8.2 | 5.8.1 | 5.8.3 | 6.6–10 | 12.2 | 12.4 | 12.6 |
| Defined milestones | 11 |  |  |  |  |  |  |  |
| Code of Good Practice | 6.13 |  |  |  |  |  |  |  |

Supplementary Table S3. Correlations between indicator scores, within dimension1 in the evaluation of sustainability of contrasting pig farming systems

|  |  |
| --- | --- |
| Dimensions and correlated indicators | Correlation |
| *Within Breeding goal and market* |  |
| Market - breeding goal and Definition sustainable  | 0.63 |
| Market - breeding goal and System’s demand | 0.75 |
| Market - breeding goal and Foresight of threats | 0.69 |
| External factors and System’s demand | 0.65 |
| External factors and Farmer’s demand | 0.55 |
| System’s demand and Farmer’s demand  | 0.64 |
| *Within Recording and selection* |  |
| Recorded traits and Estimated genetic change | 0.57 |
| *Within Genetic variation* |  |
| Effective pop size and Limit inbreeding | 0.71 |
| Effective pop size and Organisation’s interest | -0.78 |
| Effective pop size and Farmer’s interest | -0.81 |
| Effective pop size and Uniqueness of breed | -0.92 |
| Limit inbreeding and Use of OCS | 0.73 |
| Limit inbreeding and Organisation’s interest | -0.63 |
| Limit inbreeding and Farmer’s interest | -0.53 |
| Limit inbreeding and Uniqueness of breed | -0.61 |
| Organisation’s interest and Uniqueness of breed | 0.92 |
| Farmers' interest and Uniqueness of breed | 0.65 |
| *Within Management of breeding organisation* |  |
| Economic, technic resources and Human resources | 0.69 |
| Choice of methods and Human resources | 0.55 |
| Human resources and Defined mile stones | 0.63 |
| Communication, transparency and Defined milestones | 0.57 |
|  |  |

1 Non-significant correlations (*P* > 0.05) are not presented.

Supplementary Table S4. Correlations1 between average dimension2 scores in the evaluation of sustainability of contrasting pig farming systems

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dimensions | RecSel | GenVar | ManOrg | BP |
| BreGoa | 0.79\*\*\* | 0.42n.s. | 0.62\* | 0.92\*\*\* |
| RecSel |  | 0.11n.s. | 0.80\*\*\* | 0.90\*\*\* |
| GenVar |  |  | 0.13n.s. | 0.46n.s. |
| ManOrg |  |  |  | 0.83\*\*\* |

1 Significance of the correlations: ns: *P* > 0.05; \*: *P* ≤ 0.05; \*\*: *P* ≤ 0.01; \*\*\*: *P* ≤ 0.001.

2 Breeding Goal and market (BreGoa), Recording and selection (RecSel); Genetic variation (GenVar) and Management of breeding organisation (ManOrg), Overall assessment of breeding programme (BP).