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Exploration of conservation and development strategies with a limited stakeholder approach for local cattle breeds

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*Many local breeds have become endangered due to their substitution by high-yielding breeds. To conserve local breeds, effective development strategies need to be investigated. The aim of this study was to explore conservation and development strategies based on quantified strengths, weaknesses, opportunities and threats (**SWOT**) for two local cattle breeds from Northern Germany, namely the German Angler (**GA**) and Red Dual-Purpose cattle (**RDP**). The data comprised 158 questionnaires regarding both breeds' SWOT, which were answered by 78 farmers of GA and 80 farmers of RDP. First, data were analysed using the SWOT-Analytic Hierarchy Process (**AHP**) method, which combines the qualitative strategic decision tool of SWOT analysis and the quantitative tool of AHP. Second, prioritised SWOT factors were discussed with stakeholders in order to form final conservation and development strategies at breed level. For GA prioritised strengths were daily gain, meat quality, milk production and the usage of new biotechnologies, weaknesses were genetic gain in milk production and inbreeding, opportunities were organic farming and breed-specific characteristics and threats were milk prices and dependency regarding the dairy business. Consequently, three conservation and development strategies were formed: (1) changing relative weights and the relevant breeding goal to drift from milk to meat, (2) increasing genetic gain and control the rate of inbreeding by the implementation of specific selection programs and (3) selection of unique and breed characteristic components on product level, that is, milk-fat and fine muscle fibers. For RDP defined strengths were robustness, high adaptability for different housing systems and a balanced dual-purpose of milk and meat, weaknesses were inbreeding, breed extinction, genomic selection with young bulls and milk yield, opportunities were organic farming and dual-purpose aspects and threats were milk and decreasing beef cattle prices. Thus, three conservation and development strategies were identified: (1) adjust relative weights and the relevant breeding goal to balance milk and meat yield, (2) increasing genetic gain and avoid extinction by implementing targeted selection programs and (3) selection of unique and breed characteristic traits on breed level, that is, environmental robustness. Quantified SWOT establish a basis for the exploration of conservation and development strategies at breed level. Explored strategies are promising even if the stakeholder approach was limited for small populations regarding a small number of stakeholder groups. The used approach reflects farmers' individual convenience better than existing quantitative strategy decision tools on their own.*

Keywords: analytic hierarchy process, breed level, farmer, red cattle, survey

Implications

This study explores conservation and development strategies for local cattle breeds based on farmer surveys. Quantified strengths, weaknesses, opportunities and threats can be used as an ideal basis to form objective strategies at breed level. This combined approach results in promising strategies even with a limited stakeholder approach. Described approach represents farmers' individual convenience better than existing quantitative strategy decision tools on their own.

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Introduction

Many local breeds have been replaced by high-yielding breeds over the last few centuries, resulting in loss of local breeds (Meuwissen, 2009; FAO, 2010). Due to this breeding history, populations of many local breeds have dangerously decreased and some of them are even threatened by extinction (Fernández *et al.*, 2011). By now two local cattle breeds from Northern Germany are listed as endangered livestock breeds by 'The Society for the Conservation of Old and Endangered Livestock Breeds'. Both breeds are red cattle breeds with a milk-emphasised dual purpose, namely the

German Angler (**GA**) and the Red Dual-Purpose cattle (**RDP**). According to Meuwissen (2009), the best conservation strategies are an increased profitability achieved by genetic improvements and the promotion of breed-specific products. The FAO (2010) suggests a guideline to develop breeding strategies for the sustainable management of animal genetic resources also based on the implementation of effective genetic gain programs. However, Martín-Collado *et al.* (2013) explore conservation and development strategies for local European cattle breeds, which focused production systems and the marketing of new products. Thus, considered aspects in case of effective conservation strategies may be more widespread than just prioritising genetic gain. Furthermore, strategies embracing many breeds should refer to general issues, whereas specific strategies and actions for single breeds should be identified at breed level (Martín-Collado *et al.*, 2013). Investigated actions at breed level may be not only convenient for single breeds, but may also inspire the strategy decision process regarding small endangered livestock populations when done by a limited number of stakeholder groups. The aim of the present study was to explore conservation and development strategies at breed level based on quantified strengths, weaknesses, opportunities and threats (**SWOT**) for two local cattle breeds in Northern Germany.

Material and methods

Data

The data comprised comprehensive questionnaires completed by farmers, who rear one of the two local cattle breeds, namely either the GA or the RDP breed. Both breeds are local in Schleswig-Holstein, which is the most Northern state of Germany. The initial list of possible respondents consisted of 200 questionnaires (100 per breed) and was selected by the breeding organisation RSH (Rinderzucht Schleswig-Holstein e.G., Germany) due to farmers' individual breed activity and engagement. The design and sending of the questionnaires as well as the collection of completed surveys were also done by the breeding organisation. In total, 158 farmers (79%) filled out the questionnaires, thereof 78 participants for GA (78%) and 80 participants for RDP (80%). Each questionnaire consisted of a total of 12 queries, open-ended and multiple-choice questions including information on sub-items, such as farm, herd, expectations, reproduction, traits and difficulties as well as handwritten farmers' personal opinions on the breeds' SWOT (Supplementary Material S1).

Quantified strategy decision tool

To identify strategies using an organised approach, the FAO (2010) suggested employing the SWOT analysis from Weihrich (1982). A SWOT analysis is used to identify SWOT in order to enhance the profitability of an individual production system. This qualitative method has the disadvantage of high subjectivity during its application in decision-making (Hill and Westbrook, 1997; Pesonen *et al.*, 2000; Martín-Collado *et al.*, 2013). Therefore, Kurttila *et al.* (2000) and Saaty and Vargas (2001) developed a combination of the Analytic Hierarchy Process (**AHP**) method, which is a quantitative tool from Saaty (1980), and the SWOT analysis to obtain more complex and reliable decisions. This hybrid method improves the quantitative information basis and forces the decision-maker to think over and analyse the situation more precisely and in more depth (Kurttila *et al.*, 2000). SWOT-AHP methodology has been applied in the fields of forestry (Kangas *et al.*, 2001), silvopasture adoption (Shreshta *et al.*, 2004) and livestock (Wasike *et al.*, 2011).

In the current study, the SWOT-AHP was used to quantify identified SWOT. Statistical analyses and computations for eigenvalues, priority vectors and quality control parameters within the SWOT-AHP methodology were performed by using the R-software (R Core Team, 2018). The SWOT-AHP approach was divided into five steps (Figure 1) and is described below:

(I) Assignment of items
The farmers' responses were allocated as items by an expert team into four single SWOT groups of SWOT. Expert team members were previously identified through the application of certain qualification criteria. These criteria comprised: (1) long-time experiences with both local cattle breeds in practice, (2) deep knowledge of respective production systems and the local environment and (3) profound background in population genetics and management of small populations. In total, four scientists from two German animal breeding departments passed the qualification criteria, and thus, formed the team of experts. Experts discussed their attitudes and valuations as soon as they had reached consensus. The number of items and SWOT factors allocated for each SWOT group by the team of experts exhibited substantial flexibility and was allowed to differ between both breeds.

(II) Defining SWOT factors
The farmers' items were defined as SWOT factors by the expert team (Tables 1 and 2). Generally, the number of SWOT factors within each SWOT group can vary depending on the number of allocated items.

(III) Computation of priority scores for SWOT factors
The computations of the factor priority vector (**FPV**), the group priority vector (**GPV**) and overall priority vector (**OPV**) were performed with AHP rankings by the named expert team above based on the frequency of SWOT factors among farmers. The fundamental scale from Saaty (1980) was used for such AHP rankings (Table 3). This scale represented a transformation from verbal judgements into numerical judgements to determine the relative importance of each element. There were five verbal judgements, which were ranked by their importance from equal to extreme (equal, moderate, strong, very strong and extreme). These judgements were translated into the numeric values of: 1, 3, 5, 7 and 9 with four

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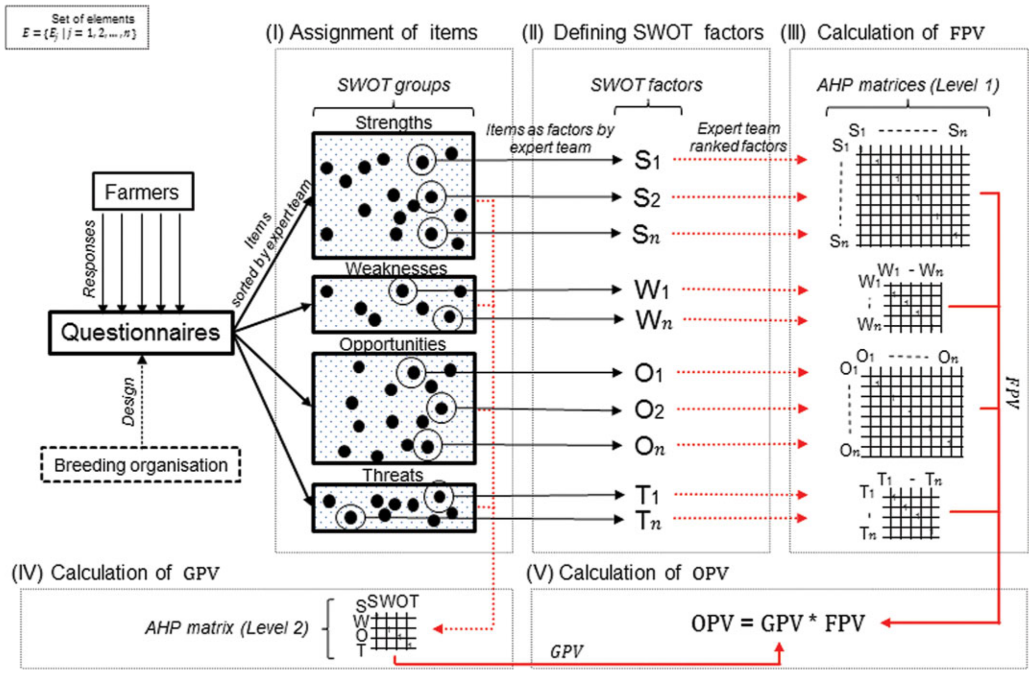

Figure 1 (Colour online) Methodical implementation of AHP based on farmer surveys for local cattle breeds. SWOT=strengths weaknesses opportunities threats; AHP=Analytic Hierarchy Process; GPV=group priority vector; FPV=factor priority vector; OPV=overall priority vector.

intermediate values (2, 4, 6, 8) for compromises in importance. In other words, the scale indicated how important or dominant one element was over another element (Saaty, 2008). The elements for FPV were individual SWOT factors within each SWOT group and for GPV the four single SWOT groups. The elements were ranked within AHP matrices of different levels: Level 1 for the SWOT factors within each SWOT group and Level 2 for the SWOT groups (Figure 1). Kahraman *et al.* (2007), Borajee and Yakchalie (2011) and Görener *et al.* (2012) defined the set of elements as $E=\{E_j \mid j=1, 2, \ldots, n\}$. The results of the n-ranked elements were resumed in an evaluation matrix A ($n * n$). Each element a_{ij} ($i, j=1, 2, \ldots, n$) was the quotient of the weights of the elements w_{ij} ($i, j=1, 2, \ldots, n$). In this matrix, the element $a_{ij}=1$, when the weights of elements $w_i=w_j$. The ranked elements were also expressed via a square and reciprocal matrix:

$$A = (a_{ij}) = \begin{bmatrix} 1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & 1 & \cdots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & 1 \end{bmatrix}; a_{ij} = \frac{w_i}{w_j}, a_{ij} \neq 0$$

Each matrix was normalised and their relative weights (A_w) were determined. The relative weights were given by the correct eigenvector (w) corresponding to the largest eigenvalue (λ_{max}), as

$$A_w = \lambda_{max} * w$$

The largest eigenvalue (λ_{max}) was computed by forming the sum of the single normalised eigenvector (w) per row multiplied by the computed priority vector per corresponding column:

$$\lambda_{max} = \sum \left(\sum_{ij} w_{(row)} * \frac{\sum_{ij} w_{(column)}}{\sum \left(\sum_{ij} w_{(column)} \right)} \right)$$

If the pairwise comparisons were completely consistent, the matrix A had rank 1 and $\lambda_{max} = n$. In this case, weights could be obtained by normalising any of the rows or columns of A. The priority vectors of FPV and GPV were computed by dividing the single normalised eigenvectors (w) per column by the sum of all single normalised eigenvectors per column for the single matrices:

$$\text{FPV/GPV} = \frac{\sum_{ij} w_{(column)}}{\sum \left(\sum_{ij} w_{(column)} \right)}$$

It should be noted that the quality of the results was related to the consistency of the comparison judgements. As a quality control, the inconsistency ratio (iCR) of the ranked elements was computed as a ratio between the consistency index (CI) and random index (RI):

$$\text{iCR} = \frac{\text{CI}}{\text{RI}}$$

The iCR provided information on the inconsistency of the ranked elements. An iCR ≤ 0.1 was acceptable as a criterion (Kahraman *et al.*, 2007; Borajee and Yakchali,

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Table 1 *Priority scores of ranked SWOT factors for GA*

SWOT group	GPV	SWOT factors	FPV	OPV
Strengths	0.375	S_1: GA herd size stay steady for the majority of farmers	0.050	0.018
	0.375	S_2: over 90% of farmers use GA as main source of income	0.053	0.019
	0.375	S_3: the majority of farmers produce their own forage for GA	0.056	0.021
	0.375	S_4: mortality rate of GA calves is low	0.059	0.022
	0.375	S_5: good adaptation of GA to marsh land	0.027	0.010
	0.375	S_6: claws and legs of GA are resilient	0.065	0.024
	0.375	S_7: GA has high resilience to climate	0.037	0.013
	0.375	S_8: GA is a milk-emphasised, dual-purpose breed with good daily gain	0.141	0.053
	0.375	S_9: GA heifers are early-maturing	0.041	0.015
	0.375	S_{10}: GA has good fertility, udder health, foundation, and carcass traits	0.098	0.036
	0.375	S_{11}: the majority of farmers uses artificial insemination for GA reproduction	0.068	0.025
	0.375	S_{12}: the majority of farmers appreciates usage of new biotechnologies for GA	0.101	0.038
	0.375	S_{13}: good meat quality of GA with slight drip losses	0.101	0.038
	0.375	S_{14}: milk of GA contains enhanced ingredients	0.040	0.015
	0.375	S_{15}: milk of GA suits cheese production very well	0.059	0.022
Weaknesses	0.162	W_1: the majority of GA farmers are conventional farmers	0.058	0.009
	0.162	W_2: the majority of GA farmers have no 'old' GA cattle (breeding type)	0.095	0.015
	0.162	W_3: GA farmers do not fatten GA bulls	0.048	0.007
	0.162	W_4: milk yield of GA is not adequate	0.129	0.021
	0.162	W_5: longevity of GA is low	0.128	0.020
	0.162	W_6: low genetic gain and inbreeding of GA	0.316	0.051
	0.162	W_7: milk yield of GA is not competitive with high-yielding breeds	0.226	0.036
Opportunities	0.278	O_1: consumers want beef of high quality	0.086	0.024
	0.278	O_2: local and organic agriculture are important to consumers	0.142	0.039
	0.278	O_3: funding of sustainable organic agriculture	0.078	0.021
	0.278	O_4: funding of local breeds by the government	0.076	0.021
	0.278	O_5: funding moved from conventional to organic farming	0.058	0.016
	0.278	O_6: higher income for farmers with local products	0.100	0.028
	0.278	O_7: enhance the economic ratio between feeding costs and milk yield for GA	0.111	0.031
	0.278	O_8: organic farming produces more benefit for farmers	0.113	0.031
	0.278	O_9: rearing GA in areas with strong climate variabilities	0.040	0.011
	0.278	O_{10}: rearing GA on marsh land	0.026	0.007
	0.278	O_{11}: increase milk protein of GA	0.062	0.017
	0.278	O_{12}: direct marketing of GA products	0.108	0.030
Threats	0.188	T_1: brand awareness of GA breed related to other local breeds is low	0.107	0.020
	0.188	T_2: insufficient local awareness of GA breed	0.107	0.020
	0.188	T_3: strong dependence on milk prices	0.230	0.043
	0.188	T_4: decreasing milk prices	0.170	0.032
	0.188	T_5: monopoly of dairy business	0.132	0.025
	0.188	T_6: establish specialised GA products on market	0.078	0.014
	0.188	T_7: some areas may be too sandy and dour for farmers' own GA forage production	0.046	0.008
	0.188	T_8: consumers' demand for breed-specific products is not high	0.131	0.024

SWOT=strengths weaknesses opportunities threats; GA= German Angler; GPV=group priority vector; FPV=factor priority vector; OPV=overall priority vector.

2011). Thus,the ranking of the elements had to be repeated by the team of experts when the iCR exceeded this threshold. The CI was computed by using the subsequent formula:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

The RI was defined as an expected value of the CI depending on an individual number of ranked elements *n*. These fixed values were obtained from the study of Aguarón and Moreno-Jiménez (2003) for further computations of the CI parameter (Table 4). The authors simulated 100,000 matrices for several sizes of n and calculated standard values for RI.

(IV) Calculation of the GPV
The GPVs were computed for each corresponding SWOT group by the expert team based on the frequency of farmers' items included in each SWOT group. Computation details for the GPV are described in step III computation of priority scores for SWOT factors.

(V) Calculation of the OPV
However, the OPVs were calculated by multiplying the single FPVs of the single SWOT factors with the

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Table 2 *Priority scores of ranked SWOT factors for RDP*

SWOT group	GPV	SWOT factors	FPV	OPV
Strengths	0.360	S_1: RDP herd size stay steady for 81% of farmers	0.040	0.014
	0.360	S_2: over 95% of farmers use RDP as main source of income	0.030	0.011
	0.360	S_3: the majority of RDP farmers produce their own forage for RDP	0.050	0.018
	0.360	S_4: the majority of RDP farmers use conventional agriculture systems	0.030	0.011
	0.360	S_5: dual purpose feature of RDP is important for RDP farmers	0.080	0.029
	0.360	S_6: the majority of RDP farmers appreciate the project work	0.060	0.022
	0.360	S_7: longevity of RDP is high	0.060	0.022
	0.360	S_8: carcass weight of RDP is good	0.090	0.032
	0.360	S_9: RDP show high robustness and adaptability to different housing systems	0.120	0.043
	0.360	S_{10}: foundation and udder quality traits of RDP are very good	0.080	0.029
	0.360	S_{11}: RDP show a balanced relation between daily gain and milk yield	0.100	0.036
	0.360	S_{12}: the majority of farmers use artificial insemination for RDP reproduction	0.030	0.011
	0.360	S_{13}: selection of RDP bulls for reproduction are made by farmers themselves	0.010	0.004
	0.360	S_{14}: RDP farmers achieve financial stability due to dual purpose	0.110	0.040
	0.360	S_{15}: carcass and meat quality of RDP is good	0.100	0.036
	0.360	S_{16}: milk of RDP contains enhanced milk protein	0.020	0.007
Weaknesses	0.137	W_1: 19% of RDP farmers will quit their agriculture farms soon	0.050	0.007
	0.137	W_2: the majority of RDP farmers do not want to exchange information	0.105	0.014
	0.137	W_3: milk yield of RDP is too low	0.100	0.014
	0.137	W_4: inbreeding and breed extinction of RDP	0.415	0.057
	0.137	W_5: farmers reject the use of genomic-tested young bulls of RDP	0.175	0.024
	0.137	W_6: milk yield of RDP is not competitive with high-yielding breeds	0.153	0.021
Opportunities	0.308	O_1: consumers want beef of high quality	0.067	0.020
	0.308	O_2: local and organic agriculture are important to consumers	0.096	0.030
	0.308	O_3: higher income for farmers with local products	0.110	0.034
	0.308	O_4: funding of sustainable organic agriculture	0.075	0.023
	0.308	O_5: funding of local breeds by the government	0.043	0.013
	0.308	O_6: high flexibility of dual-purpose breeds on changing markets	0.107	0.033
	0.308	O_7: constant market prices for beef cattle	0.037	0.011
	0.308	O_8: rearing RDP in areas with strong climate variabilities	0.038	0.012
	0.308	O_9: rearing RDP on marsh land	0.023	0.007
	0.308	O_{10}: enhance milk ingredients of RDP	0.057	0.018
	0.308	O_{11}: collaboration of RDP farmers	0.053	0.016
	0.308	O_{12}: search for organic sales markets for RDP products	0.109	0.034
	0.308	O_{13}: improve traits of fertility, udder health, and foundation of RDP	0.090	0.028
	0.308	O_{14}: increase the supply of RDP breeding bulls to the farmers	0.095	0.029
Threats	0.195	T_1: brand awareness of RDP breed related to other local breeds is low	0.055	0.011
	0.195	T_2: insufficient local awareness of RDP breed	0.053	0.010
	0.195	T_3: milk quota disappeared	0.164	0.032
	0.195	T_4: decreasing prices for beef cattle	0.132	0.026
	0.195	T_5: decreasing milk prices	0.146	0.028
	0.195	T_6: decreasing prices for beef cattle due to a massive change from milk to beef cattle production	0.230	0.045
	0.195	T_7: some areas may be too sandy and dour for farmers' own RDP forage production	0.025	0.005
	0.195	T_8: no special market for breed-specific products	0.120	0.023
	0.195	T_9: breeding goals for RDP are not achievable	0.075	0.015

SWOT=strengths weaknesses opportunities threats; RDP=Red Dual-Purpose cattle; GPV=group priority vector; FPV=factor priority vector; OPV=overall priority vector.

corresponding GPVs of each SWOT group:

$$OPV = GPV * FPV$$

The number of computed OPVs should correspond with the number of computed FPVs.

Conservation and development strategies at breed level

In general, SWOT strategies embracing single breeds should be identified at breed level (Martín-Collado *et al.*, 2013) and not just from a selected team of experts. Especially, in small endangered populations the number of experts or stakeholders is limited and a multi-stakeholder approach for single local breeds may be not achievable. Thus, identified strategies can be misleading. Furthermore, the identification of SWOT factors is often unbalanced (Karppi *et al.*, 2001) and

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Table 3 *Fundamental scale to determine the relative importance of each element for the German Angler and Red Dual-Purpose cattle by Saaty (1980) and Yüksel and Dağdeviren (2007)*

Intensity of importance	Definition	Explanation
1	Equal importance	Two criteria contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one over another
5	Strong importance	Experience and judgement strongly favour one over another
7	Very strong importance	Activity is strongly favoured and its dominance is demonstrated in practice
9	Extreme importance	Importance of one over another affirmed at the highest possible order
2, 4, 6, 8	Intermediate values	Represent compromise between the priorities listed above

Table 4 *Fixed values of RI dependent on the size of matrices to obtain strategy consistency for the German Angler and Red Dual-Purpose cattle by Aguarón and Moreno-Jiménez (2003)*

n	1	2	3	4	5	6	7	8
RI	0.00	0.00	0.525	0.882	1.115	1.252	1.341	1.404
n	9	10	11	12	13	14	15	16
RI	1.452	1.484	1.513	1.535	1.555	1.570	1.583	1.595

n=ranked elements; RI=random index.

a multi-stakeholder approach was preferred in several studies to avoid subjectivity (Impoinvil *et al*., 2007; Martín-Collado *et al*., 2013). Quantified SWOT have been identified by applying the quantified strategy decision tool of SWOT-AHP in the step before. To improve the limited amount of stakeholder groups, quantified SWOT factors with the three highest OPVs per SWOT group were comprehensively discussed face-to-face with unbiased representatives of further stakeholder groups, that is, farmers, breeders and staff of the breeding organisation (breeding board). Face-to-face discussions were performed in one group meeting with the following respective representatives: 3 (farmers), 3 (breeders) and 3 (breeding board) per breed. All representatives were equally weighted and discussed their attitudes as soon as they had reached consensus. Then promising conservation and development strategies at breed level were collectively transformed together. This formation process was refereed and protocolled by the expert team.

Results

Quantified strategy decision tool

Farmer surveys were allocated by the expert team and resulted in a total of 87 items, whereby 42 belonged to GA farmers and 45 to RDP farmers. For GA, all 42 items were divided and 15 items were subsequently sorted into the SWOT group of strengths, 7 items into weaknesses, 12 into opportunities and 8 into threats (Table 1 and Figure 2(a)). For RDP, all 45 items were divided and assigned as amounts of 16, 6, 14 and 9 into strengths, weaknesses, opportunities and threats, respectively (Table 2 and Figure 2(a)). The strengths comprised the highest number of items, whereas the weaknesses contained the lowest number of items for both breeds.

The three highest FPVs for the strengths were 0.141 for SWOT factor number 8 (S_8), 0.101 (S_{12}) and 0.101 (S_{13}) for GA (Table 1 and Figure 3(a)) and 0.120 (S_9), 0.110 (S_{14}) and 0.100 (S_{11}) for RDP. The three highest FPVs in weaknesses were 0.316 (W_6), 0.226 (W_7) and 0.129 (W_4) for GA and 0.415 (W_4), 0.175 (W_5) and 0.153 (W_6) for RDP. The three highest FPVs in opportunities were 0.142 (O_2), 0.113 (O_8) and 0.111 (O_7) for GA and 0.110 (O_3), 0.109 (O_{12}) and 0.107 (O_6) for RDP and in threats 0.230 (T_3), 0.170 (T_4) and 0.132 (T_5) for GA and 0.230 (T_6), 0.164 (T_3) and 0.146 (T_5) for RDP (Table 2 and Figure 3(a)). For GA, the computed GPVs were 0.375 for strengths, 0.162 for weaknesses, 0.278 for opportunities and 0.188 for threats (Table 1 and Figure 2(b)). However, for RDP, the calculated GPVs were 0.360 for strengths, 0.137 for weaknesses, 0.308 for opportunities and 0.188 for threats (Table 2 and Figure 2(b)).

The three highest OPVs were 0.053 (S_8), 0.038 (S_{12}) and 0.038 (S_{13}) for GA and 0.043 (S_9), 0.040 (S_{14}) and 0.036 (S_{11}) in strengths for RDP. The three highest OPVs were 0.051 (W_6), 0.036 (W_7) and 0.021 (W_4) for GA and 0.057 (W_4), 0.024 (W_5) and 0.021 (W_6) for RDP in weaknesses, 0.039 (O_2), 0.031 (O_8) and 0.031 (O_9) for GA and 0.034 (O_3), 0.034 (O_{12}) and 0.033 (O_6) for RDP in opportunities, and 0.043 (T_3), 0.032 (T_4) and 0.025 (T_5) for GA and 0.045 (T_6), 0.032 (T_3) and 0.028 (T_5) for RDP in threats (Tables 1 and 2). The three highest OPVs within each SWOT group were highlighted in the graph for each local breed (Figure 3(b)).

The iCR values for GA and RDP are shown in Figure 4. The iCR of the ranked SWOT factors within the four single SWOT groups was 0.080 for GA in strengths (iCRS), 0.066 in weaknesses (iCRW), 0.078 in opportunities (iCRO) and 0.033 in threats (iCRT). The iCR of the ranking between the SWOT groups (iCRG) was 0.001. For RDP, the iCR within each group

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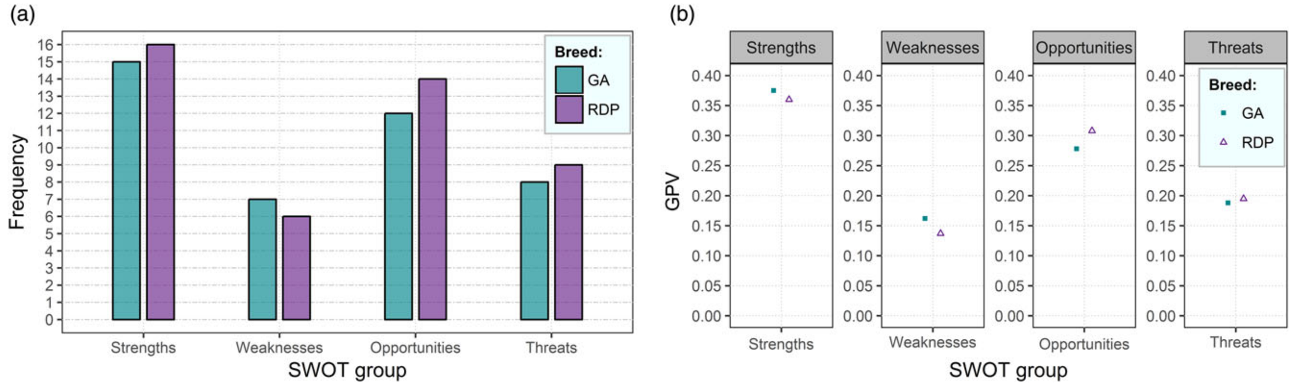

Figure 2 (Colour online) (**a**) Frequency of allocated items and (b) computed GPV via SWOT group for GA and RDP. SWOT=strengths weaknesses opportunities threats; GA=German Angler; RDP=Red Dual-Purpose cattle; GPV=group priority vector.

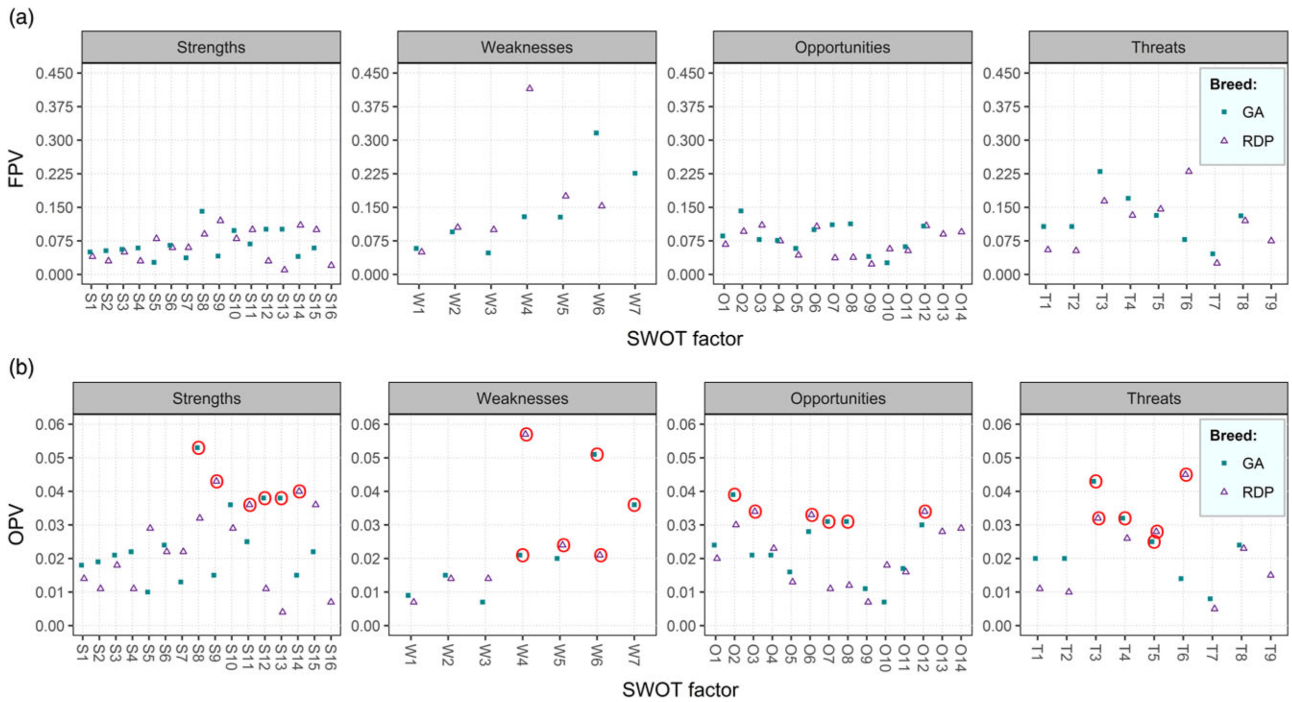

Figure 3 (Colour online) Computed (a) FPV and (b) OPV via SWOT factor for GA and RDP. SWOT factors with three highest OPVs are highlighted (red) for each SWOT group. SWOT=strengths weaknesses opportunities threats; GA=German Angler; RDP=Red Dual-Purpose cattle; FPV=factor priority vector; OPV=overall priority vector.

was 0.095 in strengths (iCRS), 0.043 in weaknesses (iCRW), 0.078 in opportunities (iCRO) and 0.060 in threats (iCRT). The iCR of the ranked four individual SWOT groups (iCRG) was 0.027.

Conservation and development strategies at breed level

Discussions with the respective stakeholder revealed for GA prioritised strengths of daily gain, meat quality, milk production and the usage of new biotechnologies. Furthermore, quantified weaknesses of genetic gain, especially for milk yield, and high rates of inbreeding have been comprehensively considered. In addition, opportunities of organic farming and breed-specific characteristics as well as threats of low milk prices and a high dependency regarding the dairy business were debated in order to explore effective conservation and development strategies at breed level.

Three final conservation and development strategies have been formulated for the GA:

(1) Changing relative weights and the relevant breeding goal to drift from milk to meat,
(2) Implementation of selection programs including genetic gain and the rate of inbreeding,
(3) Selection of unique and breed characteristic components on product level, that is, milk-fat and fine muscle fibers.

However, for RDP defined strengths were robustness, high adaptability for different housing systems and a balanced dual-purpose of milk and meat. Quantified weaknesses were

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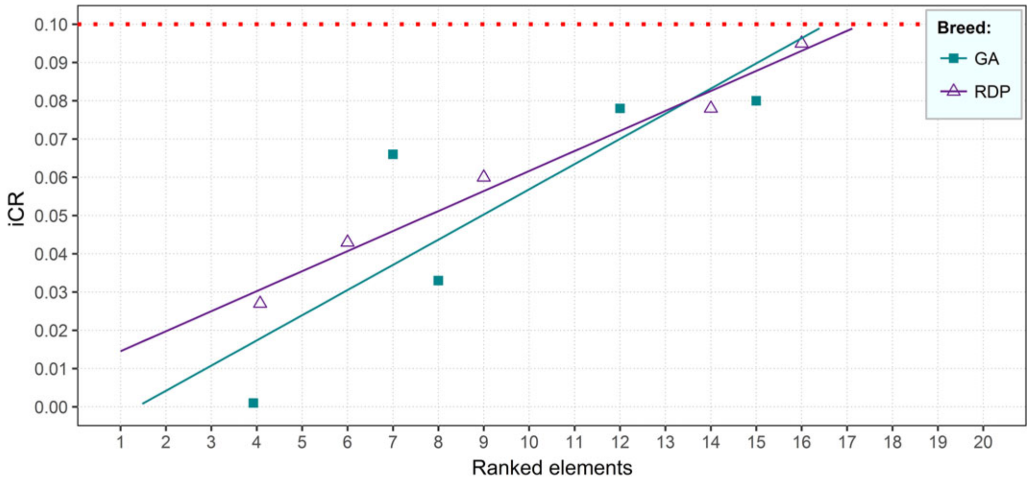

Figure 4 (Colour online) Quality control of comparison judgements via ranked elements for the GA and RDP. The threshold for the iCR is highlighted (red dotted line). GA=German Angler; RDP=Red Dual-Purpose cattle; iCR=inconsistency ratio.

inbreeding, breed extinction, genomic selection with young bulls and milk yield. Additionally, opportunities of organic farming and dual-purpose aspects as well as threats of low milk and decreasing beef cattle prices have been regarded during the strategy developments.

For RDP, three final conservation and development strategies have been formulated:

(1) Adjust relative weights and the relevant breeding goal to balance milk and meat yield,
(2) Increasing genetic gain and avoid extinction by implementing targeted selection programs,
(3) Selection of unique and breed characteristic traits on breed level, that is, environmental robustness.

Discussion

Quantified strategy decision tool

For both breeds, the quality control parameters iCRG, iCRS, iCRW, iCRO and iCRT were ≤ 0.1 (Figure 4). Hence, the quality of all comparison judgements of the ranked elements and the SWOT-AHP analysis in general were consistent. Nevertheless, the ratio between the ranked elements and iCR showed a strong dependency. The iCR was enhanced by an increased number of ranked elements. This suggests that the iCR threshold should also include the number of ranked elements to overcome limitation problems of ranked elements in order to make the AHP method more comprehensive and flexible.

Conservation and development strategies at breed level

Emphasis on meat traits will be enhanced in the breeding goal for both breeds in order to drift from milk to meat in a balanced way. Economic and biological weights as well as correlations between these traits have to be analysed in advance. Especially for the investigation of actual economic weights, product prices have to be comprehensively collected and compared on markets. Additionally, measured additive genetic variance between commercial traits is of special importance in order to assess biological weights carefully. The final identification of relative weights and the conclusive breeding goal can be indicated by using the appropriate contingent valuation method (**CVM**) from Davis (1963). CVM implies a widely used non-market valuation methodology in order to analyse environmental cost-benefits and assess environmental impacts (Cummings *et al.*, 1986; Mitchell and Carson, 1989). This method would be achievable to derive, for example, non-market values in breeding goals (Nielsen *et al.*, 2011) in case of these local breeds.

The adaptation of special breeding approaches, like the traditional or advanced Optimum Contribution Selection (Meuwissen, 1997; Wellmann *et al.* 2012), was prospectively proposed for these local breeds. The Optimum Contribution Selection is a selection method, which enables to increase genetic gain and simultaneously restrict the rate of inbreeding. This is of major importance to maintain small or endangered breeds with a threatened productivity and an enhanced rate of inbreeding (bottleneck population). Consequently, inbreeding depression and breed extinction can be avoided through mating strategies and genetic improvement. Therefore, specific breeding bulls can be suggested for mating at farm level. At this, it has major relevance that farmers follow such suggestions and attend their mating records faithfully.

Focusing unique and breed characteristic components will result in high-quality products, which can be offered on niche markets with higher earnings. Therefore, selection on such specific traits may be intensified by the breeding organisation and could lead to an added value on product level (Verrier *et al.*, 2018; Bernués, 2018; Martín-Collado *et al.*, 2018; Hiemstra *et al.*, 2018). In case of the GA, these added values on product level are milk fat (5.5%) and fine muscle fibers as meat quality trait. However, for RDP the added value will

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be not on product level but rather on the production system level following the approach from Verrier (2014) and the study of Schäler *et al.* (2018), where unique traits were investigated within the respective natural production conditions. In case of the RDP, such added value on production system level is robustness in harsh environments. Thus, the RDP may become more efficient regarding pasture feeding and health traits compared to high-yielding breeds (e.g. Holstein Friesian) under the same environmental conditions. Identified added values on product and production level may be also suitable for local or organic agriculture production schemes. Hence, dependency on commercial milk markets and prices is effectively reduced due to the concentration of niche markets, the supply of high quality products and a balanced milk–meat relation.

An implementation of all conservation and development strategies is planned for each breed. According to Gandini and Oldenbroek (2007) and Meuwissen (2009), it can be concluded that such explored strategies, which include the definition of relevant breeding goals, novel marketing products and genetic improvements, are adequate to move further from conservation to utilisation. Explored conservation and development strategies indicate promising and versatile as well as farmer- and consumer-oriented strategies at breed level, even when the number of stakeholder groups was limited. Notice, exploration and design of breeding strategies may be constrained by a biased representation of representatives per stakeholder group. However, if the representation is unbiased a small number of members may well represent a stakeholder group. Thus, it is not the number as such, but whether they are unbiased representatives of the stakeholder group as a whole that matters.

Conclusion

Quantified SWOT establish an ideal basis for the exploration of conservation and development strategies. Therefore, quantified SWOT factors have to be comprehensively discussed with further stakeholder groups and their unbiased representatives at breed level. This integrated approach results in strategies which are realistic, objective and consider individual convenience of the farmers' more than a quantitative strategy decision tool on its own.

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Declaration of interest

All authors declare that there is no conflict of interest.

Ethics statement

Animal Care and Use Committee approval was not obtained for this study because data were obtained from farmer surveys.

Software and data repository resources

None of the data were deposited in an official repository.

Supplementary material

To view supplementary material for this article, please visit http://doi.org/10.1017/S1751731119001447.

References

Aguarón J and Moreno-Jiménez J 2003. The geometric consistency index: approximated thresholds. European Journal of Operational Research 147, 137–145.

Bernués A 2018. Quantifying ecosystem services to add value in pasture-based livestock systems. 69th EAAP Book of Abstracts 24, 101.

Boraje M and Yakchali SH 2011. Using the AHP-ELECTRE III integrated method in a competitive profile matrix. In Proceedings of the 11th IPEDR, International Conference on Financial Management and Economics 2011, Singapore, pp. 68–72.

Cummings RG, Brookshire DS and Schulze WD 1986. Valuing environmental goods: a state of the arts assessment of the contingent valuation method. Roweman and Allanheld, Totowa, NJ, USA.

Davis RK 1963. The value of outdoor recreation: an economic study of the Maine woods. PhD thesis, Harvard University, Cambridge, MA, USA.

Fernández J, Meuwissen THE, Toro MA and Mäki-Tanila A 2011. Management of genetic diversity in small farm animal populations. Animal 5, 1684–1698.

Food and Agriculture Organization 2010. Breeding strategies for sustainable management of animal genetic resources. FAO Animal Production and Health Guidelines, No. 3. FAO, Rome, Italy.

Gandini G and Oldenbroek K 2007. Strategies for moving from conservation to utilisation. In Utilisation and conservation of farm animal genetic resources (ed. K Oldenbroek), pp. 29–54. Wageningen Academic Publishers, Wageningen, Netherlands.

Görener A, Toker K and Uluçay K 2012. Application of combined SWOT and AHP: a case study for a manufacturing firm. Procedia - Social and Behavioral Science 58, 1525–1534.

Hiemstra SJ, Remjin N, Hoving-Bolink AH, Amat L and Traon D 2018. Valorization of locally produced dairy and meat products from native livestock breeds. 69th EAAP Book of Abstracts 24, 102.

Hill T and Westbrook R 1997. SWOT analysis: it's time for a product recall. Long range Planning 30, 46–52.

Impoinvil DE, Ahmad S,Troyo A, Keating J, Githeko AK, Mbogo CM, Kibe L, Githure JI, Gad AM, Hassan AN, Orshan L, Warburg A, Calderón-Arguedas O, Sánchez-Loria VM, Velit-Suarez R,Chadee DD, Novak RJ and Beier JC 2007. Comparison of mosquito programs in seven urban sites in Africa, the Middle East and the Americas. Health Policy 83, 196–212.

Kahraman C, Demirel NÇ and Demirel T 2007. Prioritization of e-Government strategies using a SWOT-AHP analysis: the case of Turkey in Turkey. European Journal of Information Systems 16, 284–298.

Kangas J, Pesonen M, Kurttila M and Kajanus M 2001. A'WOT: integrating the AHP with SWOT analysis. In Proceedings of the 6th International Symposium on the Analytic Hierarchy Process 2001, Berne, Switzerland, pp. 189–198.

Karppi I, Kokkonen M and Lähteenmäki-Smith K 2001. SWOT-analysis as a basis for regional strategies. Working paper 2001, No. 4. Nordregio-Nordic Centre for Spatial Development,Stockholm, Sweden.

Kurttila M, Pesonen M, Kangas J and Kajanus M 2000. Utilizing the analytic hierarchy process (AHP) in SWOT analysis - a hybrid method and its application to a forest-certification case. Forest Policy and Economics 1, 41–52.

Martín-Collado D, Díaz C, Mäki-Tanila A, Colinet F, Duclos D, Hiemstra SJ, Eureca Consortium and Gandini G 2013. The use of SWOT analysis to explore and prioritize conservation and development strategies for local cattle breeds. Animal 7, 885–894.

Martín-Collado D, Díaz C, Serrano M, Zanoli R and Naspeti S 2018. A critical perspective on the current paradigm of high-quality products marketing strategy. 69th EAAP Book of Abstracts 24, 102.

Meuwissen THE 1997. Maximizing the response of selection with a predefined rate of inbreeding. Journal of Animal Science 75, 934–940.

Meuwissen THE 2009. Genetic management of small populations: a review. Acta Agriculturae Scandinavica, Section A–Animal Science 59, 71–79.

Mitchell RC and Carson RT 1989. Using surveys to value public goods: the contingent valuation method. Resource for the Future, Washington, DC, USA.

Nielsen HM, Olesen I, Navrud S, Kolstad K and Amer P 2011. How to consider the value of farm animals in breeding goals. A review of current status and future challenges. Journal of Agricultural Environmental Ethics 24, 309–330.

Pesonen M, Kurttila M, Kangas J, Kajanus M and Heinonen P 2000. Assessing the priorities using A'WOT among resource management strategies at the Finish Forest and Park Service. Forest Science 47, 534–541.

R Core Team 2018. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Saaty TL 1980. How to make a decision: the analytic hierarchy process. European Journal of Operational Research 48, 9–26.

Saaty TL 2008. Decision making with the analytic hierarchy process. International Journal of Services Sciences 1, 83–98.

Saaty TL and Vargas LG 2001. Models, methods, concepts and applications of the analytic hierarchy process. Kluwer Academic Publishers, Boston, MA, USA.

Schäler J, Thaller G and Hinrichs D 2018. Implementation of breed-specific traits for a local sheep breed. Agricultural Sciences 9, 958–973.

Shreshta RK, Alavalapati JRR and Kalmbacher RS 2004. Exploring the potential for silvopasture adoption in south-central Florida: an application of SWOT-AHP method. Agricultural Systems 81, 185–199.

Verrier E 2014. Some success factors for development and marketing of local breeds products. Opportunities for conservation of local breeds– WIAS Seminar, Wageningen. Retrieved on 15 January 2019 from https://www.wur.nl/upload_mm/7/f/7/d779bd35-3b92-4d17-9261-cd506db9f37d_Seminar_WIAS_Verrier_2014-12-09.pdf

Verrier E, Markey L and Lauvie A 2018. Specific products with added value for local breeds: lessons from success and non-success stories. *69th EAAP Book of Abstracts* 24, 101.

Wasike CB, Magothe TM, Kahi AK and Peters KJ 2011. Factors that influence the efficiency of beef and dairy cattle recording system in Kenya: a SWOT-AHP analysis. Tropical Animal Health and Production 43, 141–152.

Weihrich H 1982. The TOWS matrix - a tool for situational analysis. Long Range Planning 15, 54–66.

Wellmann R, Hartwig S and Bennewitz J 2012. Optimum contribution selection for conserved populations with historic migration. Genetics Selection Evolution 44, 34.

Yüksel I and Dağdeviren M 2007. Using the analytic network process (ANP) in a SWOT analysis - a case study for a textile firm. Information Science 177, 3364–3382.