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Animal welfare and biosecurity assessment: a comparison between Italian and Irish beef cattle rearing systems

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SUPPLEMENTARY MATERIALS

SUPPLEMENTARY TABLE S1. List of welfare measures included in the CReNBA beef cattle check-list for welfare and biosecurity.

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
<i>MANAGEMENT AND PERSONNEL</i>		

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
1. Number of stockpersons	1. (<i>not acceptable</i>) - 1 stockman for ≥ 800 animals 2. (<i>acceptable</i>) - 1 stockman for 400-800 animals 3. (<i>excellent</i>) - 1 stockman for ≤ 400 animals	<p><i>“Animals shall be cared for by a sufficient number of staff who possess the appropriate ability, knowledge and professional competence.”</i> (European Union Council, 1998, Annex, point 1; transposed by the Italian law D. Lgs. n. 146/2001, Annex, point 1).</p> <p>Cut-off values were defined based on national databases and individual expertise consulted by the Crenba’s staff (according to Bertocchi et al., 2018).</p>
2. Experience and training of stockpersons	1. (<i>not acceptable</i>) - Experience ≤ 10 years and no training course 2. (<i>acceptable</i>) - Experience ≥ 10 years and no training course on breeding of beef cattle 3. (<i>excellent</i>) - Experience ≥ 10 years and pertinent educational qualification or attendance to a recognized training course on breeding of beef cattle during the last 3 years	<p><i>“Animals shall be cared for by a sufficient number of staff who possess the appropriate ability, knowledge and professional competence.”</i> (European Union Council, 1998, Annex, point 1; D. Lgs. n. 146/2001, Annex, point 1).</p> <p><i>Other references:</i> Council of Europe, 2009, article 3, point 1-2; SCAHAW, 2001, Recommendations, Section A, point 1; OIE, 2017, Terrestrial Animal Health Code, Chapter 7.9, article 7.9.5, point 3, part g.</p> <p>Cut-off values were defined based on national databases and individual expertise consulted by the Crenba’s staff (according to Bertocchi et al., 2018).</p>
3. Animal grouping strategy	1. (<i>not acceptable</i>) - ≥ 40 animals per group 2. (<i>acceptable</i>) - 20-40 animals per group 3. (<i>excellent</i>) - ≤ 20 animals per group	<p><i>References:</i> Council of Europe, 2009, Appendix B, point 5-6; SCAHAW, 2001, Recommendations, Section B, point 2; SCAHAW, 2001, Recommendations, Section B, point 19; EFSA Journal 2012;10(5):2669, 3.5.4 Recommendations 1-2; OIE, 2017, Terrestrial Animal Health Code, Chapter 7.9, Article 7.9.5, point 2, part h.</p>
4. Inspections of the animals	1. (<i>not acceptable</i>) - < 1 inspection/day 2. (<i>acceptable</i>) - 1 or more inspection/day 3. (<i>excellent</i>) - More than 1 inspection/day and written report of observation or computerized registration	<p><i>“All animals kept in husbandry systems in which their welfare depends on frequent human attention shall be inspected at least once a day”</i> (European Union Council, 1998, Annex, point 2; D. Lgs. n. 146/2001, Annex, point 2).</p> <p><i>Other references:</i> Council of Europe, 2009, article 5; SCAHAW, 2001, Recommendations, Section D, point 21; OIE, 2017, Terrestrial Animal Health Code, Chapter 7.9, Article 7.9.5, point 3, part f.</p>

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
5. Type of handling	1. (<i>not acceptable</i>) - Use of harmful tools (e.g. electric goads and/or sharp instruments) 2. (<i>acceptable</i>) - Use of non-harmful tools (e.g. calm voice, hands and/or flexible plastic poles)	<i>Reference:</i> Council of Europe, 2009, article 15.
6. Diet calculation and feed quality	1. (<i>not acceptable</i>) - Empirical diet without calculation based on the needs / or the presence of summary and dated indications and/or improper food storage 2. (<i>acceptable</i>) - Diet calculated by a nutritionist and safe storage of food	<p><i>“Animals must be fed a wholesome diet which is appropriate to their age and species and which is fed to them in sufficient quantity to maintain them in good health and satisfy their nutritional needs. No animal shall be provided with food or liquid in a manner, nor shall such food or liquid contain any substance, which may cause unnecessary suffering or injury.”</i> (European Union Council, 1998, Annex, point 14; D. Lgs. n. 146/2001, Annex, point 14)</p> <p><i>Other references:</i> Council of Europe, 2009, article 12, point 1; SCAHAW, 2001, Chapter 7.3.6, Conclusions, n. 1; SCAHAW, 2001, Recommendations, Section C, point 14; EFSA Journal 2012;10(5):2669, Section 3.5.3, Recommendations, n.1; OIE, 2017, Terrestrial Animal Health Code, Chapter 7.9, Article 7.9.5, point 2, part e.</p> <p>Both conditions must be satisfied, to select the acceptable level.</p>
7. Feeding management (presence of a specific ration for each phase of the production cycle)	1. (<i>not acceptable</i>) - 1 single alimentary phase 2. (<i>acceptable</i>) - 2 dietary phases (conditioning and fattening) 3. (<i>excellent</i>) - >2 food phases (e.g. adaptation, fattening 1 st and 2 nd part, finishing)	<p><i>References:</i> Council of Europe, 2009, article 12, point 1; Galycan et al., 1999.</p> <p>Two specific feeding rations for, at least, the conditioning/post-arrival stage (usually with more forage) and the remaining fattening period (with more concentrate) must be present, to select the acceptable level.</p>
8. Feed mixing and delivery system	1. (<i>not acceptable</i>) - Not guaranteed in 24h and fractionated 2. (<i>acceptable</i>) - Guaranteed in 24h and split properly (concentrated administered at least 2 times) 3. (<i>excellent</i>) - Unifeed disposal available for 24h	<p><i>“All animals must have access to feed at intervals appropriate to their physiological needs”</i> (European Union Council, 1998, Annex, point 15; D. Lgs. n. 146/2001, Annex, point 15).</p> <p><i>Other references:</i> Boguhn et al., 2006; Iraitra et al., 2012.</p>
9. Amount of concentrates (daily dose)	1. (<i>not acceptable</i>) - Concentrates >80% of the DMI ¹ with a fibre average content < 6% 2. (<i>acceptable</i>) - Concentrates equal to 70%-80% of the DMI ¹ with a fibre average content ≥6%	<p><i>References:</i> Council of Europe, 2009, article 12, point 1; SCAHAW, 2001, Conclusions, n. 65-66; EFSA Journal 2012;10(5):2669, Section 3.5.3, Recommendations, n.2; OIE, 2017, Terrestrial Animal Health Code, Chapter 7.9, article 7.9.5, point 2, part e.</p>

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
	3. (<i>excellent</i>) - Concentrates <70% of the DMI ¹ and presence of at least 1 kg of straw or hay	
10. Water provision	1. (<i>not acceptable</i>) - Water lacking or rationing (not <i>ad libitum</i>) for one or more animals 2. (<i>acceptable</i>) - Functioning drinking bowls 3. (<i>excellent</i>) - Functioning open water troughs	<p><i>“All animals must have access to a suitable water supply or be able to satisfy their fluid intake needs by other means.”</i> (European Union Council, 1998, Annex, point 16; D. Lgs. n. 146/2001, Annex, point 16).</p> <p><i>Other references:</i> Council of Europe, 2009, article 12, point 1-2; SCAHAW, 2001, Conclusions, n. 64; OIE, 2017, Terrestrial Animal Health Code, Chapter 7.9, article 7.9.5, point 2, part e.</p>
11. Cleanliness of water points	1. (<i>not acceptable</i>) - Dirt on the surface and on the walls of bowls and water troughs 2. (<i>acceptable</i>) - Presence of feed residue only on the water surface or only on the bottom. The water is still clear 3. (<i>excellent</i>) - Absence of dirt, bowls and water troughs are clean and clear	<p><i>References:</i> Council of Europe, 2009, article 12, point 2; SCAHAW, 2001; Recommendations, Section D, point 22; Welfare Quality 2009, Chapter 5.1.1.2 (modified).</p> <p>To avoid subjective assessment, during training courses, assessors are provided with pictures and detailed guidelines to uniform the judgements, followed by a practical testing on farm, to be passed. More information is published on www.classyfarm.it (in Italian).</p>
12. Cleanliness of floors and bedding material management	1. (<i>not acceptable</i>) - Floors, lairage area and bedding material dirty and not managed in most of the pens 2. (<i>acceptable</i>) - Floors, lairage area and bedding material fairly clean and reasonably managed and/or clean slatted floors in most of the pens 3. (<i>excellent</i>) - Bedding and lairage areas very clean and dry, presence of deep litter bedding material frequently topped up in all of the pens	<p><i>“Materials to be used for the construction of accommodation, and in particular for the construction of pens an equipment with which the animals may come into contact, must not be harmful to the animals and must be capable of being thoroughly cleaned and disinfected.”</i> (European Union Council, 1998, Annex, point 8; D. Lgs. n. 146/2001, Annex, point 8).</p> <p><i>Other references:</i> Council of Europe, 2009, article 6, point 3 and article 17; OIE, 2017, Terrestrial Animal Health Code, Chapter 7.9, Article 7.9.5, point 2, part f.</p> <p>To avoid subjective assessment, during training courses, assessors are provided with pictures and detailed guidelines to uniform the judgements, followed by a practical testing on farm, to be passed. More information is published on www.classyfarm.it (in Italian).</p>

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
13. Biosecurity measures	<p>1. (<i>not acceptable</i>) - Lack of biosecurity programs or inadequate biosecurity measures, revealed by a final score in the “biosecurity assessment area” <33%</p> <p>2. (<i>acceptable</i>) - Presence of rough and inappropriate biosecurity measures, revealed by a final score in the “biosecurity assessment area” between 33.1 and 66%</p> <p>3. (<i>excellent</i>) - Presence of good and effective biosecurity measures, revealed by a final score in the “biosecurity assessment area” $\geq 66.1\%$</p>	<p><i>References:</i> Council of Europe, 2009, article 10, point 1; OIE, 2017, Terrestrial Animal Health Code, Chapter 7.9, Article 7.9.5, point 1, part a, and point 3, part g.</p> <p>This measurement is automatically inserted by the IT program based on the final score reached in the “biosecurity assessment area” (scores not yet published). Since lack of biosecurity measures can facilitate dissemination of pathogens and diseases, able to decrease the animal welfare level in case of an outbreak, an output from the “biosecurity assessment area” has been automatically inserted in the “management and personnel assessment area”.</p>
<i>HOUSING AND EQUIPMENT</i>		
14. Housing of animals older than 6 months (access to pasture)	<p>1. (<i>not acceptable</i>) - Even a single group of animals kept tied up, or kept untethered but without any kind of shelter</p> <p>2. (<i>acceptable</i>) - All the animals are loose housed, with shelter from sun and rain</p> <p>3. (<i>excellent</i>) - All the animals are loose housed with adequate shelter from sun and rain and they can have access either to an outdoor area (exercising area) or to a pasture (grazing)</p>	<p><i>“Animals not kept in buildings shall where necessary and possible be given protection from adverse weather conditions, predators and risks to their health”</i> (European Union Council, 1998, Annex, point 12; D. Lgs. n. 146/2001, Annex, point 12).</p> <p><i>Other references:</i> Council of Europe, 2009, article 9, point 6 and article 11, point 1-3; SCAHAW, 2001, Conclusions, n. 34; SCAHAW, 2001, Recommendations, Section B, point 2 and 12.</p>
15. Space availability in the lying area (m ² /animal)	<p>1. (<i>not acceptable</i>) - Available lying space (excluding feed troughs): less than 2.5 m² per animal at a weight of 400 kg (and further 0.5 m²/head for each additional 100 kg up to 800 kg), or animals kept tied up</p> <p>2. (<i>acceptable</i>) - Available lying space (excluding feed troughs): between 2.5 m² and 4.5 m²</p>	<p><i>“The freedom of movement of an animal, having regard to its species and in accordance with established experience and scientific knowledge, must not be restricted in such a way as to cause it unnecessary suffering or injury.”</i> (European Union Council, 1998, Annex, point 7; D. Lgs. n. 146/2001, Annex, point 7).</p> <p><i>Other references:</i> Council of Europe, 2009, article 11, point 1 and Appendix B, point 7; SCAHAW, 2001, Recommendations, Section B, point 6; SCAHAW, 2001, Conclusions, n. 35-36-37-38).</p>

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
	<p>per animal at a weight of 400 kg (and further 0.5 m²/head for each additional 100 kg up to 800 kg)</p> <p>3. (<i>excellent</i>) - Available lying space (excluding feed troughs): more than 4.5 m² per animal at a weight of 400 kg (and further 0.5 m²/head for each additional 100 kg up to 800 kg)</p>	
16. Type of floors and bedding materials	<p>1. (<i>not acceptable</i>) - Presence of smooth and slippery floors (either slatted or concrete)</p> <p>2. (<i>acceptable</i>) - Presence of slatted floors covered by rubber, or concrete floors with good roughness, or deep litter with a small amount of litter material</p> <p>3. (<i>excellent</i>) - Presence of deep litter with excellent organic material (abundant, non-abrasive, well preserved, absorbent)</p>	<p><i>“Materials to be used for the construction of accommodation, and in particular for the construction of pens and equipment with which the animals may come into contact, must not be harmful to the animals and must be capable of being thoroughly cleaned and disinfected. - Accommodation and fittings for securing animals shall be constructed and maintained so that there are no sharp edges or protrusions likely to cause injury to the animals.”</i> (European Union Council, 1998, Annex, points 8-9; D. Lgs. n. 146/2001, Annex, points 8-9). <i>Other references:</i> Council of Europe, 2009, article 9, point 3-4; SCAHAW, 2001, Conclusions, n. 39-40-42-43-44; SCAHAW, 2001, Recommendations, Section B, point 5; CRPA, 2004; EFSA Journal 2012;10(5):2669, Chapter 3.4.4, Conclusions, n.1 and Recommendations, n.1; OIE, 2017. Terrestrial Animal Health Code, Chapter 7.9, Article 7.9.5, point 2, part f.</p> <p>Cattle should be able to move around, even quickly, without slipping. Standing up and lying down movements should not be restricted. Behaviour expression should not be compromised.</p> <p>The assessor has to judge the floors of the pens where animals live, according to the description, considering that, in indoor fattening units, walkway areas and resting areas have usually the same surface. Slatted or solid concrete floors not covered by rubber or anything else, smooth and slippery, where animals can slip or be restricted in their movements are “not acceptable”; slatted floors covered by rubber mats, grooved concrete floors or with a small amount of litter material are “acceptable”; pens with a rich amount of straw or sawdust as deep litter (of good quality: non-abrasive, well preserved, absorbent) can be judged “excellent”.</p>
17. Electric trainers	<p>1. (<i>not acceptable</i>) - Use of electric trainers</p> <p>2. (<i>acceptable</i>) - Absence of electric trainers</p>	<p><i>References:</i> Council of Europe, 2009, article 15; SCAHAW, 2001, Conclusions, n.71; EFSA Journal 2012;10(5):2669, Chapter 3.5.4, Conclusions, n. 2.</p> <p>The usage of electric trainers, even in only one group of animals, has to be considered not acceptable.</p>

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
18. Feeding place dimension and accessibility	<p>1. (<i>not acceptable</i>) - In case of separate ration, number of feeding places < 100% of the total number of animals or, in case of total mixed ratio, number of feeding places < 70% of the total number of animals</p> <p>2. (<i>acceptable</i>) - In case of separate ration, as many feeding places as animals or, in case of total mixed ratio, number of feeding places ≥ 70% of the total number of animals</p> <p>3. (<i>excellent</i>) - Good layout of the barn, number of feeding places > 120% of the total number of animals</p>	<p><i>“Feeding and watering equipment must be designed, constructed and placed so that contamination of food and water and the harmful effects of competition between the animals are minimised.”</i> (European Union Council, 1998, Annex, point 17; D. Lgs. n. 146/2001, Annex, point 17).</p> <p><i>Other references:</i> Council of Europe, 2009, article 9, point 5; SCAHAW, 2001, Conclusions, n.22 and Recommendations, Section B, point 11.</p> <p>Feeding trough space allowance should be: ≥ 0.40 m per animal at a weight < 200 kg; ≥ 0.50 m per animal at a weight between 200-300 kg; ≥ 0.60 m per animal at a weight between 300-400 kg; ≥ 0.65 m per animal at a weight between 400-500 kg; ≥ 0.70 m per animal at a weight > 600 kg;</p>
19. Functioning and number of water points	<p>1. (<i>not acceptable</i>) - Less than 1 functioning water bowl for 13 animals or less than 6 cm of trough per animal</p> <p>2. (<i>acceptable</i>) - 1 functioning water bowl for 13 animals or 6 cm of trough per animal</p> <p>3. (<i>excellent</i>) - More than 1 functioning water bowl for 13 animals or more than 6 cm of trough per animal and different water access points</p>	<p><i>References:</i> Council of Europe, 2009, article 12, point 2; SCAHAW, 2001; Conclusions, n.64; Welfare Quality 2009, Chapter 5.2.1.2 Absence of prolonged thirst.</p>
20. Handling facilities	<p>1. (<i>not acceptable</i>) - Total lack of handling facilities</p> <p>2. (<i>acceptable</i>) - Presence and use of fixed containment alleys with open fences</p> <p>3. (<i>excellent</i>) - Presence and use of adjustable containment corridors with solid fences</p>	<p><i>References:</i> Council of Europe, 2009, article 9, points 1-7-8, and article 15; SCAHAW, 2001, Conclusions, n.23.</p>

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21. Restraint facilities (crushes or cages)	<p>1. (<i>not acceptable</i>) - Total lack of restraint facilities</p> <p>2. (<i>acceptable</i>) - Presence of non-specific but effective facilities/tools for the capture and immobilization of cattle</p> <p>3. (<i>excellent</i>) - Presence of proper squeeze crushes, specific for the capture and immobilization of cattle</p>	<p><i>References:</i> Council of Europe, 2009, article 9, point 7, and article 15; SCAHAW, 2001, Conclusions, n.77, and Recommendations, Section B, n.7; EFSA Journal 2012;10(5):2669, Chapter 3.5.6, Recommendations, n.1.</p>
22. Facilities for sick animals	<p>1. (<i>not acceptable</i>) - Lack of facilities for sick animals, or presence of pens with slatted floors without any kind of litter material</p> <p>2. (<i>acceptable</i>) - Presence of specific facilities for sick animals provided with deep litter</p> <p>3. (<i>excellent</i>) - Presence of specific facilities for sick animals, isolated from the rest of the herd, provided with well managed deep litter and registration of sick animals</p>	<p><i>“Any animal which appears to be ill or injured must be cared for appropriately without delay and, where an animal does not respond to such care, veterinary advice must be obtained as soon as possible. Where necessary sick or injured animals shall be isolated in suitable accommodation with, where appropriate, dry comfortable bedding.”</i> (European Union Council, 1998, Annex, point 4; D. Lgs. n. 146/2001, Annex, point 4).</p> <p><i>Other references:</i> Council of Europe, 2009, article 6, point 2, and article 9, point 7; SCAHAW, 2001, Conclusions, n. 84; SCAHAW, 2001, Recommendations, Section B, n.8.</p>

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
23. Temperature, humidity and ventilation conditions	<p>1. (<i>not acceptable</i>) - Inadequate temperature and humidity, or insufficient air movement, or closed buildings</p> <p>2. (<i>acceptable</i>) - Adequate temperature and humidity provided by a sufficient and natural air movement, or provided by a ventilation plant without an automatic control system</p> <p>3. (<i>excellent</i>) - Adequate temperature and humidity, sufficient air movement or ventilation and cooling plant with an automatic control system; otherwise summer pasture equipped with shelters</p>	<p><i>“Air circulation, dust levels, temperature, relative air humidity and gas concentrations must be kept within limits which are not harmful to the animals”</i> (European Union Council, 1998, Annex, point 10; D. Lgs. n. 146/2001, Annex, point 10).</p> <p><i>Other references:</i> Council of Europe, 2009, article 13, point 1; SCAHAW, 2001, Recommendations, Section B, n. 9; EFSA Journal 2012;10(5):2669, Chapter 3.4.1, Conclusions 1-2-3.</p> <p>Based on buildings’ design and eventual installation of ventilation/cooling systems, the assessor has to judge whether the barn(s) can maintain adequate ambient temperature and air circulation where animals live, to avoid heat stress.</p> <p>For instance, closed and narrow buildings with poor air circulation, neither equipped with a ventilation plant, are designated not acceptable; open buildings with a good ambient temperature and natural air circulation or buildings equipped with proper ventilation plant (with manual control) are designated acceptable; open buildings with a good ambient temperature and air circulation provided by a proper ventilation/cooling plant automatically controlled (THI sensors) are designated excellent. Otherwise, it is considered a benefit that animals can reach a summer pasture.</p>
24. Gas (NH ₃ , CO ₂ , H ₂ S) concentration	<p>1. (<i>not acceptable</i>) - NH₃ > 20 ppm, CO₂ > 3,000 ppm, H₂S > 0.5 ppm</p> <p>2. (<i>acceptable</i>) - NH₃ = 10-20 ppm, CO₂ = 1,500-3,000 ppm, H₂S < 0.5 ppm</p> <p>3. (<i>excellent</i>) - NH₃ < 10 ppm, CO₂ < 1,500 ppm, H₂S < 0.5 ppm</p>	<p><i>“Air circulation, dust levels, temperature, relative air humidity and gas concentrations must be kept within limits which are not harmful to the animals”</i> (European Union Council, 1998, Annex, point 10; D. Lgs. n. 146/2001, Annex, point 10).</p> <p><i>Other references:</i> Council of Europe, 2009, article 13, points 1-2; SCAHAW 2001, Recommendations, Section B, n.9; EFSA Journal 2012; 10(5):2669, Chapter 3.4.1, Recommendations, n.2; OIE, 2017. Terrestrial Animal Health Code, Chapter 7.9, Article 7.9.5, point 2, part c.</p> <p>To determine gas concentrations, the assessor has to measure them using a portable gas detector to be placed at the level of animals’ head.</p>

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
25. Use of artificial lighting	1. (<i>not acceptable</i>) - No artificial lighting 2. (<i>acceptable</i>) - Presence of artificial lighting 3. (<i>excellent</i>) - Presence of artificial lighting and adequate lighting (40 lux) during night-time	<p><i>“Adequate lighting (fixed or portable) shall be available to enable the animals to be thoroughly inspected at any time.”</i> (European Union Council, 1998, Annex, point 3; D. Lgs. n. 146/2001, Annex, point 3).</p> <p><i>Other references:</i> Council of Europe, 2009, article 18, point 2-3; SCAHAW, 2001, Recommendations, Section B, n.10; OIE, 2017, Terrestrial Animal Health Code, Chapter 7.9, Article 7.9.5, Section 2, part b.</p> <p>The assessor has to judge whether there is an adequate lighting (especially a fixed or portable artificial lighting for night-time) to inspect animals at any time.</p>
ANIMAL-BASED MEASURES (ABMS)		
26. Avoidance distance test	1. (<i>not acceptable</i>) - Animals cannot be approached as close as 100 cm 2. (<i>acceptable</i>) - Animals can be approached as closely as 100 to 50 cm and cannot be touched 3. (<i>excellent</i>) - Animals can be approached closer than 50 cm and can be touched	<p><i>References:</i> Welfare Quality 2009 section 5.1.4.3 Good human–animal relationship (modified); EFSA Journal 2012;10(5):2669, section 3.5.6., Conclusions n.1.</p> <p>The test has to be done at the feed bunk at a distance of 3 meters in front of the animals. A sample of animals must be assessed proportionally to the rearing stages. The assessor has to approach the single animal (having its head completely past the feeding rack / neck rail over the feed) at a speed of one step per second and a step length of approximately 60 cm with the arm held overhand at an angle of approximately 45° from the body. The assessor has to continue walking towards the animal until signs of withdrawal occur, or until he/she can touch the nose/muzzle.</p> <p>The avoidance distance is than estimated (i.e. distance between the hand and the muzzle at the moment of withdrawal) for each tested animal (score 1: > 100 cm; score 2: between 50-100 cm; score 3: < 50 cm or nose/muzzle touched). At herd level, the final result (option1, 2 or 3) is given by the average of the scores obtained.</p>
27. Behavioural interactions among animals	1. (<i>not acceptable</i>) - Presence of very frequent agonistic behaviours (> 50% of the total observed behaviours) 2. (<i>acceptable</i>) - Presence of some agonistic behaviours (10-50% of the total observed behaviours)	<p><i>References:</i> Welfare Quality 2009, 5.1.4.1 Expression of social behaviours - Agonistic behaviours and Cohesive behaviours; modified.</p> <p>The assessors has to record all the behaviours observed, dividing them in agonistic behaviours (fighting, head butt, displacement, chasing and mounting behaviours in case of males) and in cohesive behaviours (allogrooming, also known as social licking, and rubbing or horning without any obvious agonistic intention). Observation of the above mentioned behaviours are taken visually in the barn: initially, from a distant and defiladed position in order not to disturb animals, while seeing as many pens and animals as possible; afterward, during the remaining time needed to perform the other animal-based measurements.</p>

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
	3. (<i>excellent</i>) - Presence of few agonistic behaviours (< 10% of the total observed behaviours)	The observed sample of animals should always be approximately randomly distributed across the barn(s) and also within the weight categories (rearing stages). At herd level, the percentage of agonistic behaviours compared to the total observed behaviours must be calculated and reported, according to this formula: (total agonistic behaviours / (total agonistic behaviours + total cohesive behaviours)) x 100. Whether more than 50% of the total observed behaviours are agonistic behaviours is considered not acceptable.
28. Body condition score	1. (<i>not acceptable</i>) - More than 10% of animals are very lean (BCS ≤ 2) 2. (<i>acceptable</i>) - 2-10% of animals are very lean (BCS ≤ 2) 3. (<i>excellent</i>) - Less than 2% of animals are very lean (BCS ≤ 2)	<i>References:</i> NADIS (National Animal Disease Information Service): Condition Score (BCS) in beef herds; Canadian Cattleman’s Association and National Farm Animal Care Council: body condition scoring. Both systems are based on a five-point (1-5) scoring scale, where a BCS of 1 indicates an animal extremely thin and a BCS of 5 indicates an animal extremely fat. A sample of animals must be assessed proportionally to the rearing stages and the percentage of animals with BCS ≤ 2 (lean and very lean) has to be calculated and reported.
29. Cleanliness of the animals	1. (<i>not acceptable</i>) - More than 40% of animals classified “dirty” 2. (<i>acceptable</i>) - 10-40% of animals classified “dirty” 3. (<i>excellent</i>) - Less than 10% of animals classified “dirty”	<i>References:</i> Welfare Quality 2009, 5.1.2.1 Comfort around resting - Cleanliness of the animals; modified. A sample of animals must be assessed proportionally to the rearing stages and only one side of the sampled animals has to be examined (looking at: belly; underbelly, as much as is visible; flank; hindlimb). Random selection of the side of the animal observed (left or right) has to be ensured. To prevent biased results, the side selection has to be done before the examination. If not possible, the side which is seen first when approaching the animal can be chosen. The criterion for cleanliness (individual level) is the degree of dirt on the body parts considered, both covered by liquid dirt or plaques. An animal can only be classified “clean” or “dirty”: it is considered “dirty” in case of “25% of the area in question or more covered with plaques, or more than 50% of the area covered with liquid dirt”. At herd level, the percentage of animals classified “dirty” must be calculated and reported. To avoid subjective assessment, during training courses, assessors are provided with pictures and detailed guidelines to uniform the judgements, followed by a practical testing on farm, to be passed. More information is published on www.classyfarm.it (in Italian).
30. Integument alterations	1. (<i>not acceptable</i>) - More than 20% of animals with mild integument alterations	<i>References:</i> Welfare Quality 2009, section 5.1.3.1 Absence of injuries – Integument alterations (hairless patches or lesions/swellings); modified.

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
	<p>2. (<i>acceptable</i>) - 10-20% of animals with mild integument alterations</p> <p>3. (<i>excellent</i>) - Less than 10% of animals with mild integument alterations</p>	<p>A sample of animals must be assessed proportionally to the rearing stages and only one side of the sampled animals has to be examined. Random selection of the side of the animal observed (left or right) has to be ensured. To prevent biased results, the side selection has to be done before the examination. If not possible, the side which is seen first when approaching the animal can be chosen. The animal's side must be observed at a distance of about 2 meters, from the rear to the front, with particular attention to: head and neck; shoulder; forelimb (excluding inner side of the leg); thorax and abdomen; flank and hip; hindlimb (external side and inner side of the opposite hind leg).</p> <p>At individual level, based on number and type (hairless patches or lesions/swellings) of integument alterations, animals are classified as follows:</p> <ul style="list-style-type: none"> - subject with no integument alteration (no hairless patch, no lesion/swelling): up to maximum 10-15 very small hairless patches (<2 cm) or only one small hairless patch (> 2 cm but < 4 cm); - subject with mild integument alterations (but no lesion/swelling): more than 15 very small hairless patches (< 2 cm) or at least 2 to 10 small hairless patches (> 2 cm but < 4 cm), or at least a medium hairless patch (> 4 cm but < 10 cm); no lesion or swelling; - subject with severe integument alterations: 10 or more small hairless patches (>2 cm but <4 cm), or at least a large hairless patch (> 10 cm); or presence of swellings, damaged skin either in form of a scab or a wound. <p>At herd level, the percentage of animals classified “with mild integument alterations” must be calculated and reported, knowing that subjects with severe integument alterations are equal to 3 subjects with mild integument alterations.</p> <p>To avoid subjective assessment, during training courses, assessors are provided with pictures and detailed guidelines to uniform the judgements, followed by a practical testing on farm, to be passed. More information is published on www.classyfarm.it (in Italian).</p>
31. Lameness	<p>1. (<i>not acceptable</i>) - More than 6% of lame animals</p> <p>2. (<i>acceptable</i>) - 2-6% of lame animals</p> <p>3. (<i>excellent</i>) - Less than 2% of lame animals</p>	<p><i>References:</i> Welfare Quality 2009, section 5.1.3.1 Absence of injuries – Lameness; modified.</p> <p>Animals are assessed for lameness based on the following indicators.</p> <p>Evidence of lameness in moving animals:</p> <ul style="list-style-type: none"> - Reluctance to bear weight on a foot; - Uneven temporal rhythm between hoof beats, weight not borne for equal time on each of the four feet. <p>Evidence of lameness in standing animals:</p> <ul style="list-style-type: none"> - Resting a foot (bearing less/no weight on one foot); - Frequent weight shifting between feet (“stepping”), or repeated movements of the same foot; - Standing on the edge of a step. <p>A sample of animals must be assessed proportionally to the rearing stages and, at individual level, an animal is considered “lame” when showing at least one of the indicators above mentioned, in the case of either moving or standing animals.</p> <p>At herd level, the percentage of animals classified “lame” must be calculated and reported.</p>

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
32. Severe respiratory diseases (from 8 days on feed to slaughter)	1. (<i>not acceptable</i>) - More than 4% of animals with severe respiratory diseases 2. (<i>acceptable</i>) - 2-4% of animals with severe respiratory diseases 3. (<i>excellent</i>) - Less than 2% of animals with severe respiratory diseases	<p><i>References:</i> Welfare Quality 2009, 5.1.3.2 Absence of disease; modified.</p> <p>A sample of animals must be assessed proportionally to the rearing stages. Indicators of severe respiratory diseases to be considered are: <u>Dyspnoea and hampered respiration</u> [intended as deep and overtly difficult or laboured breathing; expiration supported by the muscles of the trunk, often accompanied by a pronounced sound (Welfare Quality®, 2009); in the worst cases, head and neck are extended and forelegs are spread apart with dilated nostrils and mouth open panting for air]; <u>increasing of breathing rate</u>; <u>occurrence of coughing</u> [sudden and noisy expulsion of air from the lungs (Welfare Quality®, 2009)] <u>and severe nasal discharge</u>. At individual level, an animal is considered affected by severe diseases when showing at least one of the indicators above mentioned and, at herd level, the percentage of animals classified affected by severe diseases must be calculated and reported.</p>
33. Mild enteric and/or respiratory diseases (from 8 days on feed to slaughter)	1. (<i>not acceptable</i>) - More than 20% of animals with mild enteric and/or respiratory diseases 2. (<i>acceptable</i>) - 10-20% of animals with mild enteric and/or respiratory diseases 3. (<i>excellent</i>) - Less than 10% of animals with mild enteric and/or respiratory diseases	<p><i>References:</i> Welfare Quality 2009, 5.1.3.2 Absence of disease; modified.</p> <p>A sample of animals must be assessed proportionally to the rearing stages. Indicators of mild respiratory and enteric diseases to be considered are: <u>Nasal discharge</u> [defined as clearly visible flow/discharge from the nostrils; it can be transparent to yellow/green and often is of thick consistency (Welfare Quality®, 2009)] without symptoms of dyspnoea; <u>ocular discharge</u> [defined as clearly visible flow/discharge (wet or dry) from the eye, at least 3 cm long (Welfare Quality®, 2009)]; <u>diarrhoea</u> [defined as loose watery manure below the tail head on both sides of the tail, with the area affected at least the size of a hand (Welfare Quality®, 2009)]. At individual level, an animal is considered affected by mild diseases when showing at least one of the indicators above mentioned and, at herd level, the percentage of animals classified affected by mild diseases must be calculated and reported.</p>
34. Annual mortality rate of animals (died on-farm, euthanized or emergency slaughtered)	1. (<i>not acceptable</i>) - Annual mortality rate of animals > 5% 2. (<i>acceptable</i>) - Annual mortality rate of animals between 2% and 5% 3. (<i>excellent</i>) - Annual mortality rate of animals < 2%	<p><i>References:</i> Welfare Quality 2009, section 5.1.3.2 Absence of disease – Mortality; modified; SCAHAW 2001, Chapter 6.</p> <p>Based on farm records, the number of animals which were found dead on the farm, were euthanized due to disease or accidents, or were emergency slaughtered during the last 12 months has to be compared to the number of animals reared in the fattening unit in the last year.</p>

CHECKLIST ITEM	DEFINITION	REFERENCES AND EXPLANATION
35. Mutilations (disbudding/dehornig/tail docking)	<p>1. (<i>not acceptable</i>) - Presence of mutilations not allowed (type of mutilation, procedure, documentation, age of the animal)</p> <p>2. (<i>acceptable</i>) - Presence of mutilations allowed (type of mutilation, procedure, documentation, age of the animal)</p> <p>3. (<i>excellent</i>) - Absence of mutilations</p>	<p><i>References:</i> D. Lgs. n. 146/2001, Annex, point 19; Council of Europe, 2009, article 22, points 1-2-3; SCAHAW 2001, Recommendations, n. 30-31-34-36-37; EFSA Journal 2012;10(5):2669, section 3.5.1 Mutilations; OIE 2017 Terrestrial animal health code, chapter 7.9, article 7.9.5, point 3, part e.</p>
36. Castrations	<p>1. (<i>not acceptable</i>) - Castration of animals not allowed (procedure, documentation, age of the animal)</p> <p>2. (<i>acceptable</i>) - Castration of animals allowed (procedure, documentation, age of the animal)</p> <p>3. (<i>excellent</i>) - Absence of castrations</p>	<p><i>References:</i> D. Lgs. n. 146/2001, Annex, point 19; Council of Europe, 2009, article 22, point 3; SCAHAW 2001, Recommendations, n. 31-32-33; EFSA Journal 2012;10(5):2669, section 3.5.1 Mutilations; OIE 2017 Terrestrial animal health code, chapter 7.9, article 7.9.5, point 3, part e.</p>

¹ DMI = dry matter intake

SUPPLEMENTARY TABLE S2. List of biosecurity measures included in the CReNBA beef cattle check-list for welfare and biosecurity.

“Biosecurity means a set of management and physical measures designed to reduce the risk of introduction, establishment and spread of animal diseases, infections or infestations to, from and within an animal population” (OIE 2017, Terrestrial Animal Health Code, glossary).

In this area of assessment, main strategies and management practices for decreasing biological risk in cattle are included. They are based on common biosecurity guidelines and individual expertise consulted by the Crenba’s staff.

Some references: Bertocchi and Cerioli, 2009; EFSA Journal 2012;10(5):2669, section 3.5.7.5. Disease prevention; CFIA, 2012; Sarrazin et al., 2014; OIE, 2017, Terrestrial animal health code, chapter 7.9, article 7.9.5, point 1, part a.; Damiaans et al., 2020.

BIOSECURITY MEASURES	
37. Measures for rodents and insects fighting	<p>1. (<i>not acceptable</i>) - Total lack of measures</p> <p>2. (<i>acceptable</i>) - Presence of rough and inappropriate measures</p> <p>3. (<i>excellent</i>) - Presence of good and effective measures</p>
38. Measures for preventing the entrance of strangers	<p>1. (<i>not acceptable</i>) - Total lack of measures</p> <p>2. (<i>acceptable</i>) - Presence of rough and inappropriate measures</p> <p>3. (<i>excellent</i>) - Presence of good and effective measures</p>
39. Measures for monitoring the entrance of regular visitors	<p>1. (<i>not acceptable</i>) - Total lack of precautions regarding boots and clothing of visitors</p> <p>2. (<i>acceptable</i>) - Before entering the barn, all visitors must wear disposable boot covers (even self-brought) or wear their own boots as long as used just in that specific farm</p> <p>3. (<i>excellent</i>) - At the entrance of the property, all visitors must enter a changing room and wear clothing that cannot leave the premises (e.g. disposable overalls, boots, shoe covers or own footwear and clothing just for that specific barn)</p>
40. Disinfection of vehicles entering the farm	<p>1. (<i>not acceptable</i>) - Total lack of disinfection devices</p> <p>2. (<i>acceptable</i>) - Presence of rough and not specific disinfection devices (just in case of emergency)</p> <p>3. (<i>excellent</i>) - Presence of specific and effective disinfection devices (i.e. high pressure wash down facility) used regularly</p>
41. Indirect/Direct contacts between own animals and outside vehicles delivering feed	<p>1. (<i>not acceptable</i>) - Presence of indirect/direct contacts (< 20 m distance) between own animals and outside vehicles</p> <p>2. (<i>acceptable</i>) - Absence of indirect/direct contacts (> 20 m distance) between own animals and outside vehicles</p>

42. Collection disposal of fallen stock (dead livestock)	<p>1. (<i>not acceptable</i>) - Presence of indirect/direct contacts (< 20 m distance) between own animals and dead stock collection vehicles</p> <p>2. (<i>acceptable</i>) - Absence of indirect/direct contacts (> 20 m distance) between own animals and dead stock collection vehicles; carcasses are left in a proper area on the edge of the property</p>
43. Presence of outside animals on the livestock transport vehicles	<p>1. (<i>not acceptable</i>) - The livestock transport vehicles, carrying other animals, are allowed to enter the farm</p> <p>2. (<i>acceptable</i>) - The livestock transport vehicles, carrying other animals, cannot enter the farm (they must be empty and well disinfected)</p>
44. Indirect/Direct contacts between own animals and livestock transport vehicles	<p>1. (<i>not acceptable</i>) - Presence of indirect/direct contacts (< 20 m distance) between own animals (still left in the barn) and the livestock transport vehicles</p> <p>2. (<i>acceptable</i>) - Absence of indirect/direct contacts (> 20 m distance) between own animals (still left in the barn) and the livestock transport vehicles</p>
45. Quarantine measures	<p>1. (<i>not acceptable</i>) - Total lack of quarantine measures when new animals enter the barn</p> <p>2. (<i>acceptable</i>) - Presence of rough and inappropriate quarantine measures (designated area closed to other animal housing; too short a period of time; lack of biological exams)</p> <p>3. (<i>excellent</i>) - Adoption of proper and specific quarantine measures (designated area located away from other animal housing, adequate period of time, presence of biological exams)</p>
46. Monitoring and analysis of water sources	<p>1. (<i>not acceptable</i>) - Lack of quality analysis (in case of well water)</p> <p>2. (<i>acceptable</i>) - Quality analysis performed at least once a year (in case of well water) / use of water from the town's supply system</p>

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