Final report

Hereford Information Nucleus & Young Sire Progeny Test Project

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Abstract

The final report for the Hereford Information Nucleus and Young Sire progeny Test Project outlines the project design of the BIN projects over multiple phases and a ten-year time span. With over a hundred sires progeny tested, a summary of records collected for BIN animals and of note is the significant contribution the project has made to the Hereford reference population. Animals are not only genotyped but have also been recorded for hard to measure but important traits including abattoir carcase, meat quality and feed efficiency traits. The records collected and sires tested over the life of the BIN project is documented within this report.

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1 Final report description

The final report will deliver complete details of the young sire evaluations. It will also provide an inventory of the phenotypic data collected and stored during the entire life of the project.

2 Project objectives

To progeny test approximately 15 young Hereford sires each year cohort in co-operator herds. The design and size of the project has evolved throughout the project based on funding models and evolving technologies. Extensive data was collected on BIN animals for the following information.

- Birth information – date, weight, sex, calving difficulty, gestation length.
- Weaning information – date, weight, docility score
- Post Weaning information – 400 and 600 day weights, ultrasound scanning (EMA, IMF, P8 and Rib)
- Structural Soundness – feet angle, claw set and rear legs.
- Chiller assessment – carcase weight, fat depth, eye muscle area, marble score, pH, meat colour
- Meat science lab – shear force, compression, IMF%, cooking loss
- Feed efficiency
- DNA – parent verification and SNP genotyping

3 Project Overview

3.1 Overview of project - cohorts 1 (2011) to 9 (2020)

The Hereford Information Nucleus and Young Sire progeny Test Project (BIN project) has operated for over ten years and is on-going with matings for cohort 11 currently underway. During the course of the BIN project there have been three distinct phases. The first two phases received MLA Donor Company funding and the current phase self-funded by Herefords Australia Limited (HAL).

Phase 1 (2011 – 2014) - MLA Donor Company funding

The first phase of the BIN project produced four cohorts of progeny from 12 Hereford co-operator herds were located across southern Australia (south-east of South Australia to southern-western Queensland). Within each year there were eight co-operator herds participating representing southern (VIC and SA) and northern (NSW and QLD) Hereford herds. The project design was essentially to mate cows via Artificial Insemination (AI) to progeny test approximately 15 sires each cohort. Both southern and northern herds used the same sires, and reared progeny to weaning before HAL purchased the steers. Post weaning steers from the southern and northern regions were managed together throughout backgrounding, feed lotting and slaughter.

Phase 2 (2015 – 2017) - MLA Donor Company funding

The second phase of the BIN project produced three cohorts of progeny from six Hereford co-operator herds. Within each year there were between two and five co-operator herds participating, with the larger herds located in the southern region. The project design was similar to the first phase, but post weaning the steers were not pooled together for backgrounding, feed lotting and slaughter.

Instead, post weaning management was undertaken on a herd level and in practice varied depending on the herd circumstances. For example, a group of steers may be backgrounded in a location other than the birth herd, but the contemporary group structure was maintained through to slaughter.

Phase 3 (2018 – 2022+) – Self-funded by Herefords Australia Limited

The third and current phase was self-funded by HAL and is currently ongoing. Two cohorts have been slaughtered, with another three cohorts at different stages. Again, the project design was like previous phases with two key co-operator herds participating.

Project calves were the result of AI using project sires and, in some herds, additional naturally mated animals. Calves were reared under standard conditions for the co-operator herd and were recorded for a large number of traits including existing BREEDPLAN traits, but steers were also backgrounded (grass or grain) and Net feed intake, abattoir carcase and UNE meat quality measurements collected. HAL funded the additional costs of collecting records (i.e., feed intake tests and ultrasound scanning). To help off-set the AI costs, co-operator herds received a fee per calf at 400 days of age, paid by the owner of the AI bull being progeny tested.

3.1.1 Participating herds

Registered and commercial breeders were able to express an interest in being a co-operator herd for the Young Sire progeny Test Project. Most co-operator herds became involved in phase 1 and the two co-operator herds currently producing BIN progeny have been involved across all three phases. Table 1 outlines the herds participating in the project.

Table 1: Herds participating in the Hereford Information Nucleus and Young Sire progeny test project including the length of involvement, location and available cow information.

Herd	Herd Name	S/N[1]	Cohorts	Location	Cow herd information[2]
Y1001	John Wyld	S	1	SW VIC	NPR
Y1002	Waterloo Grazing Pty Ltd	S	1	SE SA	NPR
Y1003	Roly Day	S	1-3	SE SA	NPR
Y1004	Tarcombe Herefords	S	1, 3-11	VIC	NPR
Y1005	Wirruna Poll Hereford Stud	N	1-4a	S NSW	PR
Y1006	Yalgoo Partnership	N	1-3	NE NSW	NPR
Y1007	KA & HE Blake	N	1-4a, 5	NE NSW	NPR
Y1008	Koomoorang Past Co	N	1-4a	E NSW	NPR
Y1009	BN & JM Bell & Sons	S	2-11	SE SA	NPR
Y1010	John Windeyer	N	2	E NSW	PR
Y1011	Hornet Bank Past Co	N	2	SE QLD	NPR
Y1012	Tondara	N	4	S NSW	PR
Y1013	Europambela	N	6-7	NE NSW	NPR

Y1014[3]	Melon Pastoral	N	6	E NSW	NPR
Y1015	King Island Cattle Company	S	6-7	TAS	NPR

[1] Southern (May/Jun joining) or Northern (Oct/Nov joining) herd

[2] Non-performance recorded (NPR) or Performance recorded (PR) cows

[3] This herd was predominately cross-bred so was not included into the BREEDPLAN database. The herd only participated in Cohort 6 group of animals and won't be considered further in this report

Co-operator herd selection criteria

In phase 1 of the project, expressions of interest were sought from potential co-operator herds. Herds had to have 50 or more cows available for the project, suitable production, and management practises to weaning and agree to collecting data using project protocols. The cows available to the project were required to be Hereford but did not need to be pedigree performance recorded cows. In most co-operator herds the cows were commercial with little pedigree and performance information known about them. A limitation of using commercial cows is that only half the genetic contribution of project animals was known, and we need to assume that all cows were essentially the same and this may reduce statistical power. However, performance cows are valuable and therefore difficult to source for use in a BIN project. Ensuring sufficient progeny numbers per sire can provide statistical power to analyse data that does not have a significant maternal contribution, i.e., later in life traits like abattoir carcase traits. Traits like 200 day weight where there is a significant maternal effect will be impacted by this design, as the use of a commercial dam will not enable the maternal effect to be estimated. The target number of co-operator herds in phase 1 was eight – four from both southern and northern regions. With some exceptions there were two co-operator herds included on phases 2 and 3. In total, there were 15 co-operator herds recruited into the project over the three phases. These herds were involved for differing time points and represented different regions (northern or southern).

3.1.2 Project sires

Nominations for sires were open to all HAL members. From these nominated sires approximately 15 sires were identified to use each year for AI mating in co-operator herds. Cows that do not conceive to the AI bulls are then mated to the back-up bulls used in the co-operator herds. Sires were identified to represent the diversity present in the Hereford population, with particular caution not to only use sires with genetics at one end of the distribution as this would cause bias and reduced variation in the analysis. Within a sire team, care was also taken to provide linkage to previous cohorts and key industry projects. In particular, the sires selected for cohort 6 were linked to the Hereford black baldy trial and the NZ maternal productivity trail and in recent cohorts' linkage with the Southern Multi-breed project are considered with BIN sire details provided to Southern multi-breed for consideration in their sire choices. At all BIN phases there was consultation between HAL and other stakeholders in the selection of sires. The owners of sires that are included provide semen at no cost and agree to pay a fee to the relevant co-operator herds for each calf reaching 400 days to help offset the cost of producing BIN animals for the progeny test.

Over ten cohorts, 114 different sires produced 10 or more BIN progeny. These sires sired 3,490 of the reference animals and a full list of sires is included in the Appendix. The average number of progeny per sire was 31, ranging between 10 and 118 progeny per sire. Sires were predominately AI sires but there were also natural mated bulls with 10 or more progeny. In total, there were 903 animals with sire unknown in the BREEDPLAN database. Within cohorts, the number of animals with unknown sire was quite small – especially for calves produced with AI - with most unknown sires coming from herd Y1009 who included a large number naturally mated cows. However, genotyping undertaken in this herd may help resolve the parentage of calves from these natural matings. Sires with 10 or more progeny were born between 2002 and 2017 with 81.6% of all sires were born 2008 or later. There were 82 unique sires of the reference sires, the largest contribution these sires had was that there were four different sires that each had four sons selected as reference sires.

All AI sires were parent verified and genotyped.

3.1.3 Project animals

The BIN projects have collected information from 4,577 animals over three phases, ten birth cohorts (2011-2020) and 14 co-operator herds, with more cohorts underway. The table below characterises the number of animals recorded by herd and birth cohort. In phase 1, more herds participated (n = 5 to 8) with the later phases being smaller and focused on two main co-operator herds. The animals recorded are mostly purebred Hereford with a small number of animals from herd Y1013 being 75% Hereford. In most cases the cows were commercial non-performance recorded animals, although in phase 1 there were three co-operator herds that utilised performance recorded cows. HAL are continuing to self-fund the scheme and the matings to produce cohort 11 due to calve in 2022 are currently underway. Herd Y1009 contributed extra animals to the BIN project via natural mating, and this can be seen in the higher progeny numbers in this herd from 2014 onwards. All calves in the project, especially the calves produced via AI, were sire verified with later cohorts being genotyped as well.

Table 2: The number of animals recorded by herd and cohort as part of the Hereford Information Nucleus and Young Sire progeny test project.

		Phase 1				**Phase 2**			**Self-funded**			
	Cohort (birth year)	**1 (11)**	**2 (12)**	**3 (13)**	**4a (14)**	**4b (15)**	**5 (16)**	**6 (17)**	**7 (18)**	**8 (19)**	**9 (20)**	**Total**
	Y1001	120										**120**
	Y1002	16										**16**
	Y1003	82	77	57								**216**
	Y1004	78		84	92	65	109	64	94	87	97	**770**
	Y1005	46	47	41	60							**194**
Herd	**Y1006**	31	27	32								**90**
	Y1007	43	54	51	22		17					**187**
	Y1008	30	43	34	48							**155**
	Y1009		92	154	460	121	166	346	188	397	412	**2336**
	Y1010		24									**24**

	Y1011		17									**17**
	Y1012			83								**83**
	Y1013							100	44			**144**
	Y1015							129	96			**225**
	TOTAL	**446**	**381**	**536**	**682**	**186**	**292**	**639**	**422**	**484**	**509**	**4577**
AI prog		**426**	**357**	**475**	**315**	**163**	**260**	**321**	**242**	**203**	**242**	**3004**

3.1.4 Traits recorded.

Co-operator herds were briefed on data collection protocols to ensure that the traits were recorded according to best practice. All data was stored in the HAL data located at ABRI database. This included the traits incorporated into existing BREEDPLAN evaluations and those yet to be included i.e., meat quality. The following section outlines the records collected on BIN animals.

3.1.4.1 Calving traits

Information was collected on all animals at birth. This included dates of birth, sex, birth weight, calving difficulty and if the calf was born dead or alive. The accurate recording of dead calves provides an opportunity to look at calf survival work.

Gestation length was recorded from AI sired calves, as the number of days between conception (AI insemination date) and the date of birth for the resulting calf. Birth weight was recorded on animals at birth within 24 hours of birth using scales. Both traits are included in the BREEDPLAN genetic evaluation and standard deviations indicate that there is variation in the data collected.

Calving difficulty was scored for each calf on a 1 to 6 scale: unassisted (1), easy pull (2), hard pull (3), surgical assistance (4), Mal-presentation (5) and elective surgical (6). Nearly 4,000 calving difficulty records were collected, and in most years, the majority of calves were born with no assistance.

Table 3: Summary of the raw records collected for gestation length (days) and birth weight (kg)

	Gestation length (days)					**Birth weight (kg)**				
Cohort (birth year)	**N**	**mean**	**std**	**min**	**max**	**N**	**mean**	**std**	**min**	**max**
1 (2011)	392	283.4	4.8	271	304	428	40.6	5.9	24	61
2 (2012)	347	283.2	5.3	264	300	365	40.6	6.2	21	61
3 (2013)	438	283.3	4.8	267	302	500	39.6	5.8	20	66
4a (2014)	281	284.4	4.9	273	302	335	38.9	5.8	20	53
4b (2015)	163	284.0	6.0	273	303	177	38.1	4.7	27	50
5 (2016)	243	281.8	5.5	268	302	283	37.0	6.1	23	57

6 (2017)	307	283.1	5.3	271	303	621	39.4	7.5	16	62
7 (2018)	236	283.1	6.5	267	302	399	37.7	7.8	16	56
8 (2019)	199	280.6	4.3	270	294	363	33.0	5.2	20	50
9 (2020)	230	280.7	4.9	271	292	500	34.8	5.5	19	57
Total	**2836**	**282.9**	**5.3**	**264**	**304**	**3971**	**38.1**	**6.7**	**16**	**66**

Table 4: Summary of the raw records collected for calving difficult (1-6 score)

Cohort (birth year)	N	**1**	**2**	**3**	**4**	**5**	**6**	**% No assistance**
1 (2011)	433	419	5	2	3	4	0	96.8
2 (2012)	363	354	1	4	1	3	0	97.5
3 (2013)	500	492	1	2	0	5	0	98.4
4a (2014)	339	335	1	1	0	2	0	98.8
4b (2015)	186	184	1	0	0	1	0	98.9
5 (2016)	291	246	34	3	0	7	1	84.5
6 (2017)	466	440	17	3	0	6	0	94.4
7 (2018)	290	284	5	0	0	1	0	97.9
8 (2019)	478	465	10	0	0	3	0	97.3
9 (2020)	511	476	20	7	1	7	0	93.2
Total	**3854**	**3692**	**95**	**22**	**5**	**39**	**1**	**95.8**

3.1.4.2 Live weights

Live weights were recorded for 200, 400 and 600 day live weight and these were included into the routine BREEDPLAN genetic evaluation. Over the ten-year period, the standard deviations demonstrate that there was lots of variation observed within the BIN animals. All animals were weighed for 200 and 400 day but in phase 1 only the females were recorded for 600 day weight as the steers had been moved off co-operator herds for backgrounding and finishing. In the later phases all animals were weighted for 600 day weights and a summary of the live weight data collected is shown in Table 5. Animals born in 2020 have yet to have live weight information added to the HAL database.

3.1.4.3 Docility, condition and muscle scores of live animals

A number of scored traits on live animals have been collected in the BIN project (Table 6). In phase 1 and 2, temperament was assessed by scoring docility on a 1 (calm) to 5 (aggressive) scale. In all cohort years the majority of animals scored 1 and 2 for docility. Phase 2 and 3 animals were condition scored based on a 1 (leaner) – 6 (fatter) scoring system and all phases assessed the muscle score on a A+ to E- scale for animals. In these metrics, animals tended to have condition scores of 3 or 4 and were in the C muscle score grades.

Table 5: Summary of the raw records collected for 200, 400 and 600 day live weights (kg)

	200 day (kg)					400 day (kg)					600 day (kg)				
Cohort (birth year)	**N**	**mean**	**std**	**min**	**max**	**N**	**mean**	**std**	**min**	**max**	**N**	**mean**	**std**	**min**	**max**
1 (2011)	566	261.9	59.1	101	432	409	379.2	79.8	211	620	228	493.9	101.5	334	730
2 (2012)	370	278.0	52.5	115	408	434	440.0	106.9	201	700	239	492.9	92.4	300	770
3 (2013)	503	218.5	61.5	61	379	416	441.3	96.3	218	678	153	483.4	77.1	351	698
4a (2014)	334	243.4	43.9	72	349	171	406.3	55.0	278	552	240	515.3	98.6	300	752
4b (2015)	297	265.1	46.5	148	396	142	501.6	80.1	319	688					
5 (2016)	197	259.6	42.4	161	360	154	355.1	61.9	202	560	212	542.9	98.8	362	726
6 (2017)	475	228.0	31.9	152	330	461	321.6	63.3	153	536	450	482.6	94.4	306	762
7 (2018)	340	210.1	55.0	75	394	162	324.4	63.3	226	499	383	498.2	123.9	290	788
8 (2019)	375	253.3	36.7	165	376	469	359.2	62.6	215	598	272	563.5	106.6	335	781
Total	**3457**	**245.0**	**54.3**	**61**	**432**	**2818**	**388.3**	**94.7**	**153**	**700**	**2177**	**507.3**	**105.5**	**290**	**788**

Table 6: Summary of the raw records collected for docility, condition and muscle scores of live animals.

	Docility Score (1-5)						Condition Score (1-6)							Muscle Score (A+ - E-)								
Cohort (birth year)	**N**	**1**	**2**	**3**	**4**	**5**	**N**	**1**	**2**	**3**	**4**	**5**	**6**	**N**	**B-**	**B**	**C-**	**C**	**C+**	**D-**	**D**	**D+**
1 (2011)	356	49	266	34	7		47		2	27	18			158	3		7	55	89			4
2 (2012)	372	148	211	12	1		39		1	19	18	1		274	3		57	122	85	1	2	4

3 (2013)	344	99	212	27	6	34	8	19	7		262			75	78	28	1	10	70
4a (2014)	314	104	198	11	1	28	1	19	7	1	218			24	70	63	1	17	43
4b (2015)	88	51	23	6	8						88	1		23	25	14	6	3	16
5 (2016)	210	89	104	13	4	91		7	82	2	91			9			1	13	68
6 (2017)	209	95	96	10	8	113	3	64	46		238	2		34	61	59	5	41	36
7 (2018)						101	2	44	55		213	2		22	65	74		26	24
8 (2019)						227		174	52	1	39			1	25	13			
Total	**1893**	**635**	**1110**	**113**	**35**	**680**	**17**	**373**	**285**	**5**	**1581**	**11**		**252**	**501**	**425**	**15**	**112**	**265**

Table 7: Summary of the raw records collected for Feet angle of the front and rear feet.

	Feet Angle – Front foot										Feet Angle – Rear foot									
Cohort (birth year)	**N**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**N**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1 (2011)	244					74	156	14			244				1	28	185	27	3	
2 (2012)	286				2	80	150	45	8	1	286				2	26	183	70	4	1
3 (2013)	274					65	167	36	6		274					29	164	76	5	
4a (2014)	245					75	157	12	1		245				1	23	152	60	9	
4b (2015)	88					12	69	7			88					3	41	44		
5 (2016)	91					25	51	13	2		91				1	3	60	26	1	
6 (2017)	238				1	71	146	19		1	238					12	147	77	2	

7 (2018)	213					45	141	27			213					6	133	74	27	12
8 (2019)	39					10	26	3			39						27	12		
Total	**1718**				**3**	**457**	**1063**	**176**	**17**	**2**	**1718**				**5**	**130**	**1092**	**466**	**24**	**1**

Table 8: Summary of the raw records collected for Claw set of the front and rear feet.

	Claw set – Front foot										**Claw set – Rear foot**									
Cohort (birth year)	**N**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**N**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1 (2011)	244					19	186	37	2		244					31	194	19		
2 (2012)	286				3	18	163	85	17		286				8	44	192	41	1	
3 (2013)	274			1	5	30	166	68	1	3	274			5	39	54	151	22	2	1
4a (2014)	245				9	26	172	35	3		245			2	30	43	140	23	5	2
4b (2015)	88				9	9	43	27			88			1	36	13	36	2		
5 (2016)	91					14	47	29	1		91					9	65	16	1	
6 (2017)	238				2	20	146	65	4	1	238				12	42	162	21	1	
7 (2018)	213				1	23	146	43			213			1	9	53	135	15		
8 (2019)	39					1	29	8	1		39					1	30	8		
Total	**1718**			**1**	**29**	**160**	**1098**	**397**	**29**	**4**	**1718**			**9**	**134**	**290**	**1105**	**167**	**10**	**3**

Table 9: Summary of the raw records collected for the rear legs with a hind and side view.

	Rear Legs – Hind view										Rear Legs – Side view									
Cohort (birth year)	**N**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**N**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1 (2011)	244					29	211	4			244					37	202	5		
2 (2012)	286					104	167	14	1		286			3	6	91	161	24	1	
3 (2013)	274				1	73	147	51	2		274					109	97	53	15	
4a (2014)	245				3	80	122	37	3		245				4	121	69	45	6	
4b (2015)	88				1	1	15	58	12	1	88				3	1	9	39	31	5
5 (2016)	91					14	77				91				1	48	42			
6 (2017)	238				5	39	148	44	2		238				14	79	65	72	8	
7 (2018)	213					17	138	56	2		213				6	82	42	74	9	
8 (2019)	39					9	30				39					27	12			
Total	**1718**				**10**	**366**	**1055**	**264**	**22**	**1**	**1718**			**3**	**34**	**595**	**699**	**312**	**70**	**5**

3.1.4.4 Structural soundness

Structural soundness was assessed by scoring the feet angle (Table 7) and claw set (Table 8) of the front and rear legs and assessing the rear legs (Table 9) from a hind and side view. Each of the traits was scored on a 1 to 9 scale. This collection of structure soundness traits constitutes approximately 20% of the total structural soundness data recorded in the Hereford database, and significantly have been collected on animals with good contemporary grouping structure maximising the value of the records.

3.1.4.5 Heifer and steer ultrasound carcase composition

All BIN cohorts were routinely ultrasound scanned for fat depth at P8 and Rib sites (Table 10) intra-muscular fat percent and eye muscle area (Table 11). Although the raw phenotype averages vary across cohorts due to different environmental effects, in all years there appear to be variation observed in cohorts and no cohorts had a lot of skinny animals.

Table 10: Summary of the raw records collected for ultrasound fat depth at P8 and RIB sites

	P8 fat depth (mm)					**RIB fat depth (mm)**				
Cohort (birth year)	**N**	**mean**	**std**	**min**	**max**	**N**	**mean**	**std**	**min**	**max**
1 (2011)	364	9.0	3.7	3	19	364	7.1	2.7	3	14
2 (2012)	315	11.5	4.3	3	21	316	9.4	3.6	2	18
3 (2013)	304	9.0	4.0	2	19	301	6.7	2.7	2	13
4a (2014)	249	10.2	4.2	3	22	242	7.5	2.6	2	15
4b (2015)	86	12.5	2.8	7	18	87	9.1	2.3	5	16
5 (2016)	198	13.3	3.8	5	23	195	8.9	2.2	3	14
6 (2017)	321	9.4	4.9	3	21	316	6.4	2.5	2	12
7 (2018)	213	11.2	6.9	3	28	216	7.6	3.5	2	20
8 (2019)	204	6.9	4.1	2	21	208	5.4	3.0	2	14
Total	**2254**	**10.1**	**4.8**	**2**	**28**	**2245**	**7.4**	**3.1**	**2**	**20**

Table 11: Summary of the raw records collected for ultrasound eye muscle area and intra-muscular fat percent.

	Eye muscle area (cm)					Intra-muscular fat percent (%)				
Cohort (birth year)	**N**	**mean**	**std**	**min**	**max**	**N**	**mean**	**std**	**min**	**max**
1 (2011)	364	68.6	9.4	42	96	363	4.4	1.6	0.5	7.4
2 (2012)	318	70.0	10.1	47	95	317	5.3	1.5	0.8	8.2
3 (2013)	309	64.7	12.2	39	91	309	4.3	1.8	0.5	7.9
4a (2014)	248	67.6	12.2	42	96	251	4.4	1.6	0.5	7.7
4b (2015)	88	76.6	9.1	52	97	88	5.5	0.7	4.1	7.0
5 (2016)	209	71.8	9.3	52	93	209	5.3	1.6	1.0	7.7
6 (2017)	325	62.3	12.0	38	89	323	4.6	1.7	0.5	7.9
7 (2018)	214	69.9	12.1	44	98	215	5.0	1.8	0.5	8.0
8 (2019)	209	65.2	10.1	45	88	213	3.2	1.9	1.0	7.5
Total	**2284**	**67.7**	**11.4**	**38**	**98**	**2288**	**4.6**	**1.8**	0.**5**	**8.2**

3.1.4.6 Abattoir carcase composition

A key set of traits that have been measured in the Hereford BIN projects has been abattoir carcase traits. Over the life of the BIN projects approximately 1,500 abattoir carcase records have been collected and this accounts for approximately half the carcase records recorded in the HAL database. Importantly, these abattoir carcase traits were collected on animals from a structured design with a good contemporary group structure, maximising the values of the data collected. As well as traits of interest a number of slaughter fixed effects were also recorded in the HAL database, but not always for all cohorts or animals. These fixed effects include kill site, body number, dentition, boning group and quartering site. Abattoir carcase traits are included into the BREEDPLAN genetic evaluation with the trait's carcase weight, eye muscle area, fat depth (P8 and RIB) and intra-muscular fat (IMF% and marbling score) included (Tables 12, 13 and 14).

Table 12: Summary of the raw records collected for Abattoir carcase weight and eye muscle area.

	Carcase weight (kg)					Eye muscle area (cm)				
Cohort (birth year)	**N**	**mean**	**std**	**min**	**max**	**N**	**mean**	**std**	**min**	**max**
1 (2011)	194	308.2	36.9	203	384	194	68.5	6.1	51	81
2 (2012)	178	323.4	36.8	206	439	139	74.3	5.7	64	90
3 (2013)	230	331.4	30.6	260	418	229	76.4	6.8	61	93
4a (2014)	149	314.3	32.8	239	409	145	73.4	7.1	58	91
4b (2015)	83	299.5	34.4	216	376	83	70.9	6.1	59	84
5 (2016)	104	331.3	26.4	277	400	104	84.3	8.2	67	117
6 (2017)	291	290.4	37.5	203	412	291	74.7	8.8	46	111
7 (2018)	167	356.5	27.5	266	415	150	83.1	8.3	59	107
8 (2019)	169	335.3	30.4	242	422	130	83.6	6.4	67	100
Total	1565	319.8	38.9	203	439	1465	76.1	8.8	46	117

Meat samples were collected from BIN animals to be assessed in the UNE meat science laboratory. A range of traits was measured including shear force tenderness measurements (Tables 15 to 19). The BIN projects have collected almost 1,400 shear force records and this constitutes a large proportion of the available information for an important eating quality trait. For a lot of meat quality traits the BIN animals represent the entire data set for traits like ossification, MSA index and cooking loss, and are approaching a volume which may make analysis of the data meaningful. For example, as a direct result of the BIN projects a shear force tenderness EBV may be possible based on the outcome of data analysis. Due to the COVID pandemic restricting movements, meat samples for 2019 BIN animals from herd Y1009 were not possible.

Table 13: Summary of the raw records collected for Abattoir carcase fat depth (P8 and Rib) and intra-muscular fat percent

Cohort	P8 fat depth (mm)					RIB fat depth (mm)					Intra-muscular fat percent (%)				
(birth year)	N	mean	std	min	max	N	mean	std	min	max	N	mean	std	min	max
1 (2011)	194	16.5	5.8	3	32						194	4.3	1.4	1.6	11.6
2 (2012)	139	17.7	4.1	5	30						139	4.1	1.2	1.9	8.6
3 (2013)	228	15.5	4.0	7	26	226	9.2	3.6	3	23	229	4.3	1.4	2.0	9.0
4a (2014)	147	14.4	4.3	6	27	148	9.3	3.9	3	19	148	3.2	1.4	1.6	8.3
4b (2015)	83	19.0	5.7	10	35	82	8.4	3.4	3	22	83	3.8	1.2	2.3	7.8
5 (2016)	104	18.4	3.7	11	29	104	9.0	3.0	4	19	104	4.4	1.2	2.4	7.8
6 (2017)	271	13.0	5.1	3	27	291	7.7	2.9	2	18	291	3.7	1.2	1.7	7.6
7 (2018)	112	18.1	5.5	10	34	165	9.5	3.7	1	21	167	5.2	1.8	2.0	11.5
8 (2019)	130	17.3	4.3	8	29	169	8.2	2.7	3	14	169	5.8	1.5	2.0	10.8
Total	**1408**	**16.1**	**5.1**	**3**	**35**	**1185**	**8.6**	**3.4**	**1**	**23**	**1524**	**4.3**	**1.6**	**1.6**	**11.6**

Table 14: Summary of the raw records collected for Abattoir carcase marbling on Ausmeat and MSA scoring systems

	Ausmeat marble score							MSA / USDA marble score					Old MSA marble score				
Cohort (birth year)	**N**	**0**	**1**	**2**	**3**	**4**	**5-9**	**N**	**mean**	**std**	**min**	**max**	**N**	**mean**	**std**	**min**	**max**
1 (2011)	194	68	118	8				194	298.8	60.2	130	470					
2 (2012)	139	20	85	29	5								139	3.6	0.5	2.5	4.9
3 (2013)	233	17	169	41	5	1							223	3.7	0.6	2.0	6.0
4a (2014)	151	19	109	19	4			149	346.7	23.8	230	520					
4b (2015)	87	13	71	3				83	327.8	39.9	230	440					
5 (2016)	104	2	83	19				104	360.5	43.2	270	490					
6 (2017)	291	58	211	22				291	321.6	49.7	140	450					
7 (2018)	167	10	99	53	5			167	358.4	77.8	100	530					
8 (2019)	169	4	78	83	4			169	365.3	82.7	100	560					
Total	**1535**	**211**	**1023**	**277**	**23**	**1**		**1157**	**336.6**	**65.5**	**100**	**560**	**362**	**3.6**	**0.6**	**2.0**	**6.0**

Table 15: Summary of the raw records collected for MSA index, shear force and carcase ossification

Cohort	MSA index (30-80)					Shear force					Carcase ossification (100-200)				
(birth year)	N	mean	std	min	max	N	mean	std	min	max	N	mean	std	min	max
1 (2011)	194	61.2	1.3	57.2	64.6	194	3.7	0.8	2.3	5.9					
2 (2012)	139	64.0	1.8	57.1	68.4	139	3.4	0.8	2.4	7.1					
3 (2013)	230	63.6	1.6	58.8	68.4	231	3.4	0.5	2.4	5.3					
4a (2014)	143	62.1	1.7	58.1	66.3	149	3.7	0.7	2.6	7.9	151	134.5	12.7	100	190
4b (2015)	87	61.7	2.5	55.7	65.7	81	3.9	1.4	2.4	10.3	87	139.2	31.6	100	200
5 (2016)	104	62.5	1.3	59.0	65.8	104	3.4	0.4	2.6	4.5	104	130.8	12.5	100	170
6 (2017)	275	60.7	1.7	56.9	65.5	290	3.2	0.6	1.7	5.0	291	136.2	18.1	100	190
7 (2018)	165	62.2	2.0	55.5	66.9	166	3.0	0.5	2.1	5.1	167	139.9	17.7	100	180
8 (2019)	169	61.8	2.2	55.0	66.6	39	3.1	0.5	2.4	5.2	169	141.0	18.4	100	180
Total	**1506**	**62.1**	**2.1**	**55.0**	**68.4**	**1393**	**3.4**	**0.7**	**1.7**	**10.3**	**969**	**137.1**	**18.7**	**100**	**200**

Table 16: Summary of the raw records collected for cooking loss and carcase pH

Cohort (birth year)	Cooking loss (%)					Carcase pH					Carcase lab pH				
	N	**mean**	**std**	**min**	**max**	**N**	**mean**	**std**	**min**	**max**	**N**	**mean**	**std**	**min**	**max**
1 (2011)	194	25.1	3.4	16.4	39.7	194	5.5	0.08	5.3	5.7	194	5.5	0.05	5.4	5.7
2 (2012)	139	22.2	3.8	8.5	32.1	139	5.5	0.11	5.4	6.3	139	5.5	0.10	5.4	6.4
3 (2013)	230	22.6	2.4	15.9	28.5	233	5.5	0.09	5.3	5.9	231	5.6	0.06	5.4	5.7
4a (2014)	150	23.8	2.7	12.8	29.9	150	5.5	0.10	5.4	5.9	150	5.6	0.05	5.5	6.0
4b (2015)	85	23.5	1.9	19.7	28.1	83	5.6	0.11	5.4	5.9	85	5.5	0.04	5.4	5.6
5 (2016)	104	23.6	2.3	17.4	29.4	104	5.5	0.06	5.4	5.7	104	5.6	0.06	5.5	5.7
6 (2017)	260	23.2	2.6	16.7	34.0	291	5.6	0.12	5.3	6.2	290	5.6	0.13	5.4	6.1
7 (2018)	166	22.5	2.1	18.3	27.3	167	5.5	0.08	5.2	5.7	166	5.6	0.07	5.4	6.0
8 (2019)	38	24.2	2.0	18.6	28.7	169	5.6	0.09	5.3	5.7	39	5.6	0.04	5.5	5.7
Total	**1366**	**23.3**	**2.9**	**8.5**	**39.7**	**1530**	**5.5**	**0.10**	**5.2**	**6.3**	**1398**	**5.6**	**0.09**	**5.4**	**6.4**

Table 17: Summary of the raw records collected for abattoir meat and fat colour

	Carcase meat colour								Carcase fat colour						
Cohort (birth year)	**N**	**1B**	**1C**	**2**	**3**	**4**	**5**	**6**	**N**	**0**	**1**	**2**	**3**	**4**	**5**
1 (2011)	194	25	130	36	3				194		94	94	6		
2 (2012)	139	16	50	68	3		1	1	139	41	95	3			
3 (2013)															
4a (2014)	150	1	30	65	46	7		1	150	28	51	61	10		
4b (2015)	83			5	46	28	2	2	83	74	9				
5 (2016)	104	2	22	40	37	3			104	84	19	1			
6 (2017)	291	1	22	45	104	105	12	2	291	78	48	105	60		
7 (2018)	167		12	44	104	7			167	30	59	52	22	4	
8 (2019)	169	5	12	64	85	3			169	76	69	18	5		1
Total	**1297**	**50**	**278**	**367**	**428**	**153**	**15**	**6**	**1297**	**411**	**444**	**334**	**103**	**4**	**1**

Table 18: Summary of the raw records collected for meat colour assessed in the lab

Cohort	Carcase meat colour - L					Carcase meat colour - A					Carcase meat colour - B				
(birth year)	N	mean	std	min	max	N	mean	std	min	max	N	mean	std	min	max
1 (2011)	194	42.3	2.4	36.6	49.2	194	23.4	1.5	18.6	27.8	194	11.1	1.0	7.9	13.5
2 (2012)	139	43.1	2.7	31.8	49.8	139	23.7	1.7	12.7	27.4	139	11.1	1.0	4.2	12.9
3 (2013)	231	41.5	2.1	35.5	49.9	231	22.9	1.6	18.7	27.3	231	10.7	0.9	8.1	12.8
4a (2014)	150	40.3	2.2	32.0	45.7	150	23.0	1.6	14.0	26.1	150	10.3	1.2	4.9	13.1
4b (2015)	85	40.7	2.2	35.5	46.1	85	23.0	1.5	19.1	26.1	85	10.1	1.1	6.9	12.0
5 (2016)	104	41.7	2.0	36.9	47.8	104	24.5	1.3	21.7	28.2	104	11.5	0.8	9.9	13.6
6 (2017)	290	41.6	2.7	34.2	48.5	290	23.0	2.1	15.3	29.1	290	10.6	1.4	4.7	14.1
7 (2018)	166	42.1	2.3	36.1	47.3	166	24.2	1.5	20.5	28.4	166	11.0	1.2	8.1	14.5
8 (2019)	38	42.0	2.5	36.6	48.1	38	23.7	1.5	19.8	26.7	38	11.3	1.2	7.1	13.8
Total	**1397**	**41.7**	**2.5**	**31.8**	**49.9**	**1397**	**23.4**	**1.7**	**12.4**	**29.1**	**1397**	**10.8**	**1.2**	**4.2**	**14.5**

Table 19: Summary of the raw records collected for carcase muscle score

	Carcase muscle score (A+ to E-)								
Cohort (birth year)	N	**B-**	**B**	**C-**	**C**	**C+**	**D-**	**D**	**D+**
1 (2011)	194		5	32	138	2	2	5	10
2 (2012)	139		1		135			3	
3 (2013)									
4a (2014)									
4b (2015)									
5 (2016)	104		7		97				
6 (2017)	96				96				
7 (2018)	78		5		73				
8 (2019)									
Total	611		18	32	539	2	2	8	10

3.1.4.7 Net feed intake

The cost of feed is significant making feed efficiency an important, but hard to measure, trait of interest. Feedlot Net Feed Intake (NFI) is constructed by adjusting the daily feed intake for the metabolic mid weight and average daily gain. It is expected that the population has an average phenotype of 0 with both negative and positive phenotypes observed. The phenotypes collected by the BIN project are all negative with the positive NFI values in the population being measured in the 1990's. The NFI records collected as part of the BIN project are the only recent source of feed efficiency records and account for almost 70% of all the Hereford feed efficiency records.

Table 20: Summary of the raw records collected for feedlot Net feed Intake (NFI)

	NFI (kg/day)				
Cohort (birth year)	**N**	**mean**	**std**	**min**	**max**
1 (2011)	63	-2.64	0.84	-4.50	-0.94
2 (2012)	93	-3.19	0.88	-5.34	-0.73
3 (2013)	231	-3.47	1.15	-7.95	-0.27
4a (2014)	54	-4.00	1.12	-8.62	-1.79
4b (2015)					
5 (2016)	106	-2.72	0.77	-4.26	-0.58

6 (2017)	51	-2.85	0.90	-7.09	-1.37
7 (2018)	74	-3.91	2.03	-9.32	-0.50
Total	**672**	**-3.28**	**1.24**	**-9.32**	**-0.27**

3.1.5 Genotyping

All AI sires utilised in the project were both parent verified and themselves genotyped. Their progeny were also sire verified but not necessarily genotyped. The sire verification process was until recently undertaken by microsatellites or a small SNP subset instead of utilising higher density SNP panels.

In the current Hereford single-step genetic evaluation, there are nearly 35,000 genotyped animals included in the G matrix. This includes all genotypes including those of recent born selection candidates that are yet to be phenotypes and contribute to the reference population. Overall, 2,385 BIN animals were genotyped and contributing to the G matrix and more importantly the Hereford reference population. Very few animals in phase 1 were genotyped due to the restrictively high cost of genotyping at the time. Now the cost of genotyping has dramatically decreased, almost all animals were genotyped from 2015 onwards, usually at 50K density, with the latest years being at 150K. Overall the BIN phases, 136 sires were genotyped. Sires were genotyped at higher density, depending on the technology available at the time. Sires tended to be genotyped at 50K and 140K.

The table below outlines the number of animals within a cohort year, how many were genotyped and on what platform. These genotypes are accompanied by high quality phenotypes as outlined in the previous sections; in particular, they represent a unique subset of animals with meat eating quality traits recorded on genotyped animals.

Table 21: Summary of the genotyping undertaken within the BIN cohorts.

Cohort (birth year)	N animals	N AI progeny	N genotyped	Genotype platform
1 (2011)	446	426	199	GGP_SUPERLDV4_30k
2 (2012)	381	357		
3 (2013)	536	475	2	GGP_HEREFORD_ULD_30k
4a (2014)	682	315	3	GGP_HEREFORD_ULD_30k GGP_BOVINE_50K GGP_HDV2_140k
4b (2015)	186	163	154	GGPV3_25k GGPV32_26k
5 (2016)	292	260	246	GGP_SUPERLDV4_30k GGP_BOVINE_50K
6 (2017)	639	321	528	GGP_BOVINE_50K
7 (2018)	422	242	343	GGP_BOVINE_50K

8 (2019)	484	203	452	GGP_BOVINE_50K GGP_BOVINE_100K
9 (2020)	509	242	458	GGP_BOVINE_100K
Total	**4577**	**3004**	**2385**	

4 Conclusions/recommendations

The Hereford Information Nucleus and Young Sire progeny Test Project (BIN project) has operated for over ten years and is still on-going with matings for cohort 11 currently underway. The initial phases received MLA Donor Company funding but since 2018, Herefords Australia Ltd have self-funded the BIN project with two co-operator herds. A sizable dataset has accrued over the life of the project. In particular, the BIN project represents the Hereford's primary data for key economic traits abattoir carcase, meat quality and feed efficiency. With BIN animals genotyped, they make a valuable contribution to the reference data for Hereford.

5 Appendix

5.1 Sires with 10 or more progeny in the BIN program

sire	sire_hbn	sireyob	grandsire	grandsire_hbn	11	12	13	14	15	16	17	18	19	20	Total
0					5	13	9	340	23	6	152	113	82	160	903
200423857	216088132	2008	200398644	216066199	6	9									15
200424106	216088406	2008	200372833	677040283	32										32
200592459	216133062	2013	200449450	216100408							21				21
200517833	272110089	2011	200378066	281050218							32				32
200740061	677150368	2015	200630757	677131040									12		12
11706061	AEDD1	2008	11645111	AEDA74	38						2				40
1477125	BMED36	2008	1433098	BMEA24	29										29
12002713	BMEK32	2014	11744898	WNAF382								2	14		16
12216496	BMEM003	2016	11676568	MTTC8									18		18
11720706	BWND203	2008	11551544	AEDW168		17									17
11639551	BWNZ260	2004	200266467	0147S0138	27	10									37
11732912	CDEE27	2009	11678175	SBDB1			40								40
12202152	CDEM003	2016	11891300	OSA43214853AHR								25			25
11777321	CHSG38	2011	11617226	SBPZ933				44	13		2				59
11948243	CRKJ106	2013	1498145	YPHF181							23				23
11737691	DAYE312	2009	11672189	VALA61			36								36
11797116	DAYH38	2012	11706061	AEDD1				33	15						48
11969265	DAYK103	2014	11891286	OSA43269958AHR							32				32
12095490	DAYL142	2015	11922574	DAYJ59								42			42
12361125	DAYN102	2017	200688262	US43500058									28		28
12172417	DRHM011	2016	11676568	MTTC8									16		16
11728253	EKIE02	2009	11684241	WTAC80				22	14						36
11881674	HRPJ051	2013	200353269	347033060						28					28
12062887	HRPL336	2015	12063367	OSA43335233AHR								39			39
1499653	IHSE078	2009	1427070	FLDZ251		22									22
11866065	IHSJ188	2013	11738026	AEDE114						19					19
12049386	IHSK220	2014	11738026	AEDE114							21				21
1407508	IHSY203	2003	1335925	IHSV093	39										39
11742460	JSBF41	2010	11575862	LHBX155				33	15						48
11847137	KIDH273	2012	11725713	WNAE327						25					25
11666475	KMPB184	2006	11594225	MTTY12	16										16

11699136	KMPC223	2007	11549011	LHBW203		22									22
11732705	KMPE212	2009	200366483	277044110		22									22
11775995	KMPG241	2011	11741704	MIH4RAPR						30					30
11997195	KMPK24	2014	11741704	MIH4RAPR							16				16
12071149	KMPL204	2015	11676568	MTTC8								5	16	11	32
12145605	KMPL255	2015	11676568	MTTC8									1	13	14
12194642	KMPM110	2016	11844533	KMPH284									21		21
12316814	KMPM347	2016	11841108	OSA43002897AHR										12	12
12458259	KMPN224	2017	11957504	WNAK74										11	11
11745216	M60F31	2010	200345164	889030047			41								41
11776183	MTTH34	2012	200353269	347033060								41			41
11929368	MTTK22	2014	11776253	MTTH16							8	5	10		23
11594225	MTTY12	2003	11585398	PEF821CAPR	28										28
12039661	PRRL058	2015	11772709	DAYG74								22			22
1481612	RSHD651	2008	11551544	AEDW168	34			10	18						62
11872879	RSHJ162	2013	11740820	BWNE332						12	13				25
1478496	SKLD001	2008	1431745	ARGA001		31									31
11737768	SODE316	2009	11543844	SCBV086			36								36
11774729	SODG075	2011	1464827	GRKC093							25				25
11926898	SODJ157	2013	11841108	OSA43002897AHR							22				22
11960517	THSK021	2014	11744898	WNAF382								11	9		20
11960508	THSK022	2014	11744898	WNAF382								27	7		34
11960462	THSK035	2014	1499812	YPHF107							28				28
12208241	THSM049	2016	11869785	WNAJ13									15	8	23
12271091	THSN131	2017	11741704	MIH4RAPR										17	17
12340540	THSN213	2017	11957351	WNAK137										19	19
11717360	VALD50	2008	11691757	VALB45		29									29
11732613	WCPE032	2009	11538006	RMTNGA37HCHR		34									34
1493742	WCPE140	2009	1336827	CHAV592			33								33
11754598	WCPF112	2010	1469622	INBC225			34								34
11773637	WCPG040	2011	11617226	SBPZ933				46	16						62
11773774	WCPG101	2011	1493725	WCPE110				31	17						48
11878367	WCPJ121	2013	11773805	WCPG128						36					36
11985705	WCPK044	2014	11785427	OSA2943647CHR							25				25
11715456	WKHD543	2008	11551544	AEDW168			46								46
11730587	WKHE522	2009	11617226	SBPZ933		20									20
11743753	WLMF145	2010	11684233	WLMC196			33								33

11743703	WLMF203	2010	11684029	WLMC82			29								29
11687505	WNAC26	2007	200303566	216000219	30	14									44
11687526	WNAC68	2007	11525584	WNAV16	35										35
11705534	WNAD1	2008	11594225	MTTY12	34										34
11725607	WNAE210	2009	1423243	GAH17NCHR		32									32
11725572	WNAE99	2009	11597954	SBPY781		36									36
11744764	WNAF195	2010	200303566	216000219			34	6							40
11744573	WNAF214	2010	11609694	OPCY118			48								48
11765527	WNAG134	2011	11687353	WNAC280				37	12						49
11765113	WNAG171	2011	11705534	WNAD1				32	14						46
11792779	WNAH47	2012	11732705	KMPE212						35					35
11869785	WNAJ13	2013	200416049	281070390						32					32
11862428	WNAJ55	2013	11597954	SBPY781						31					31
11957154	WNAK326	2014	11792639	WNAH297							107			11	118
11957504	WNAK74	2014	11744573	WNAF214							20	8			28
12045277	WNAL477	2015	200353269	347033060								38			38
12158528	WNAM010	2016	11744573	WNAF214									50		50
12158171	WNAM288	2016	11738026	AEDE114									49		49
12297896	WNAN049	2017	11957154	WNAK326										31	31
12297592	WNAN191	2017	11744898	WNAF382										24	24
1450612	YAVB241	2006	11597954	SBPY781			12								12
1477818	YAVD026	2008	1423243	GAH17NCHR	30										30
1489459	YAVE199	2009	11597954	SBPY781		27					7				34
1508691	YAVF313	2010	11692946	VALB56			54								54
1512738	YAVG031	2011	11692946	VALB56				36	22						58
11869201	YAVJ018	2013	11732705	KMPE212							10	3	1		14
11869142	YAVJ072	2013	1508691	YAVF313						25					25
11964564	YAVJ452	2013	11701744	WKHC558							13				13
12013324	YAVK115	2014	11795494	OSA2953537CHR							27	6		6	39
12012602	YAVK214	2014	200416049	281070390							10				10
12013282	YAVK269	2014	11692946	VALB56							9	1	7		17
12037975	YAVK401	2014	11766459	KMPG45							2	4	4	14	24
12038000	YAVK478	2014	11766459	KMPG45									11		11
12154392	YAVL417	2015	12064273	OSA43377074AHR										31	31
12282444	YAVM250	2016	11766459	KMPG45									17		17
12282482	YAVM259	2016	11766459	KMPG45									1	15	16
12264904	YAVM293	2016	11862473	WNAJ134									17		17

12264869	YAVM332	2016	11838903	YAVH491					17		17
12264910	YAVM445	2016	12013324	YAVK115					24		24
12421979	YAVN233	2017	11960453	THSK067						15	15
12415436	YAVN325	2017	11791192	HYAH427						20	20
12415318	YAVN374	2017	12142096	YAVL001						28	28
1460368	YPHC091	2007	1427070	FLDZ251	27	11					38
1489835	YPHE025	2009	1384205	YPHX122		30					30
1498145	YPHF181	2010	1466790	HRPC041			44	4			48
1384205	YPHX122	2002	1307755	YPHU047	30			1			31