Nutrient Profiling – Mineral Supplementation

Pre- and Postnatal Trace Mineral Supplement Source on Heifer and Bull Performance and Sexual Development

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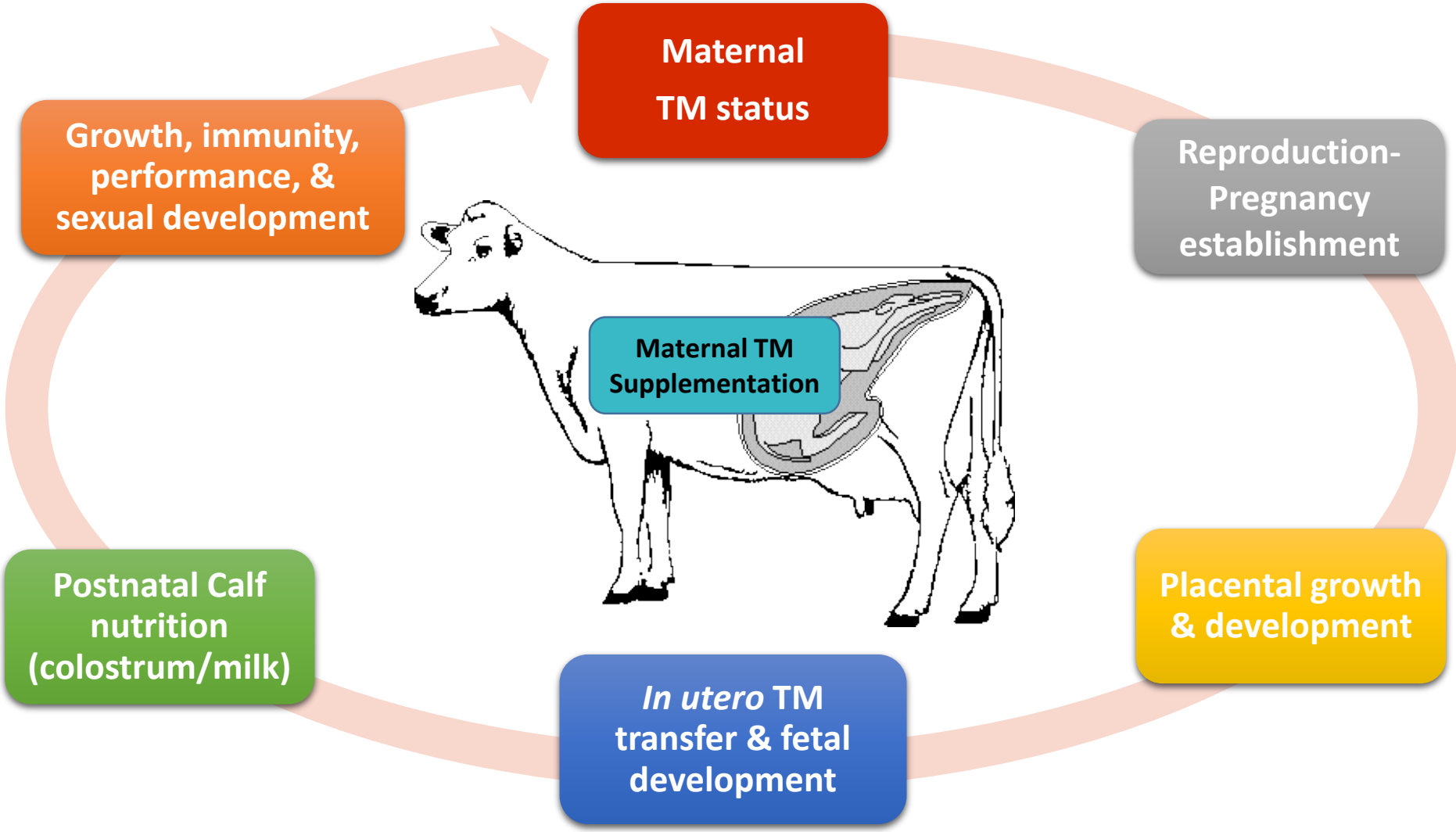
Introduction

- Trace minerals (TM) are essential nutrients involved in physiological & biochemical processes
  - Metabolism, immunity, growth, & reproduction (Hidiroglou, 1979; Spears, 2000; Suttle, 2010)
- TM source of either organic or inorganic, affects mineral bioavailability (Spears, 1996)
- Maternal nutrition during gestation may impact the developing fetus & can potentially affect postnatal animal (Ashworth and Antipatis, 2001; Hostetler et al., 2003)

Influence of Trace Minerals on Cow-Calf Production Cycle



Experiment Rationale

- Examination of long-term effects of prenatal and postnatal TM source & cattle breed on neonatal and growing calves, and heifer & bull sexual development are warranted

Objectives

1. Investigate effects of TM source over 2 production cycles on cow TM status, performance, & reproduction
2. Examine effects of prenatal & postnatal cow TM source on
    1. Neonatal & growing calf TM status, performance, & immunity
    2. Weaning calf TM status, performance, & acute phase response (APR) to a weaning stressor
3. Study effects of prenatal & postnatal TM source on
    1. Heifer sexual development
    2. Bull sexual development

Experimental Design

- Starting 82 ± 2 d pre-calving in yr 1
- ***Breed***: pregnant Angus (AN) & Brangus (BN) cows
- ***TM source***
  - Inorganic (ING, Na selenite & salt sulfates)
  - Organic (ORG, Se-yeast & proteinates)
- TM supplement (Co, Cu, Mn, Se, Zn) fed 3x/wk
    - Pre-calving to breeding: ***Pellet*** (0.4 kg/454 kg BW/d)
    - Breeding to weaning: ***Loose mineral*** (0.09 kg/cow/d)

Experimental Design

- **2 Production cycles:** cows remained same TM treatments assigned in Yr 1
  - Yr 1 cows, *n* = 199
    - ING-AN = 49, ING-BN = 51, ORG-AN = 50, ORG-BN = 49
  - Yr 2 cows; *n* = 161
    - ING-AN = 41, ING-BN = 44, ORG-AN = 38, ORG-BN = 38
- Resultant calves used additional experiments
  - Neonatal & growing calf performance & immunity
  - Heifer sexual development
  - Bull sexual development

- **Study effects of prenatal & postnatal TM source on heifer sexual development**
  - **Puberty**
  - **Pregnancy**

Materials & Methods

- Yr 1: *n* = 80; 20 heifers/treatment
- Yr 2: *n* = 61; ING-AN = 16, ING-BN = 15, ORG-AN = 14, & ORG-BN = 16
- 28 d intervals
  - BW, BCS (scale 1-9), & hip height (HH)
- 84 d intervals
  - Liver biopsy for TM analysis (Co, Cu, Fe, Mn, Mo, Se, & Zn)
    - Yr 1 = 6 heifers/treatment
    - Yr 2 = 5 heifers/treatment

Materials & Methods

- Weekly blood samples
  - Progesterone (PROG) determination by RIA
- Pregnancy confirmed by transrectal ultrasonography
  - Days 51, 72, & 107 from start of natural service breeding season (yr 1 = 71 d; yr 2 = 72 d)
- Definitions
  - **Puberty** = date when PROG ≥ 1.5 ng/mL with one of next two weekly blood samples with PROG ≥ 1.5 ng/mL
  - **Pregnancy** = first date of three consecutive weekly blood samples with PROG ≥ 1.5 ng/mL and confirmed by estimated age based on ultrasound pregnancy diagnosis

Year 1 Heifers

Year 1 Physical Characteristics of Heifers at Start of 168 d Development Period

	Trace mineral (TM) × Breed (B)					*P*-value		
Variable	AN-ING	BN-ING	AN-ORG	BN-ORG	SEM	TM	B	TM × B
n	20	20	20	20				
Age	233	233	234	239	5	0.45	0.60	0.54
BW, lb	472	485	492	496	11	0.18	0.40	0.71
BCS	4.3[a]	4.6[b]	4.6[b]	4.7[b]	0.1	**< 0.01**	**< 0.01**	**0.02**
HH, cm	106.6	110.8	106.7	111.6	0.9	0.63	**< 0.01**	0.70

[a, b] = Means within a row differed, $P \leq 0.05$

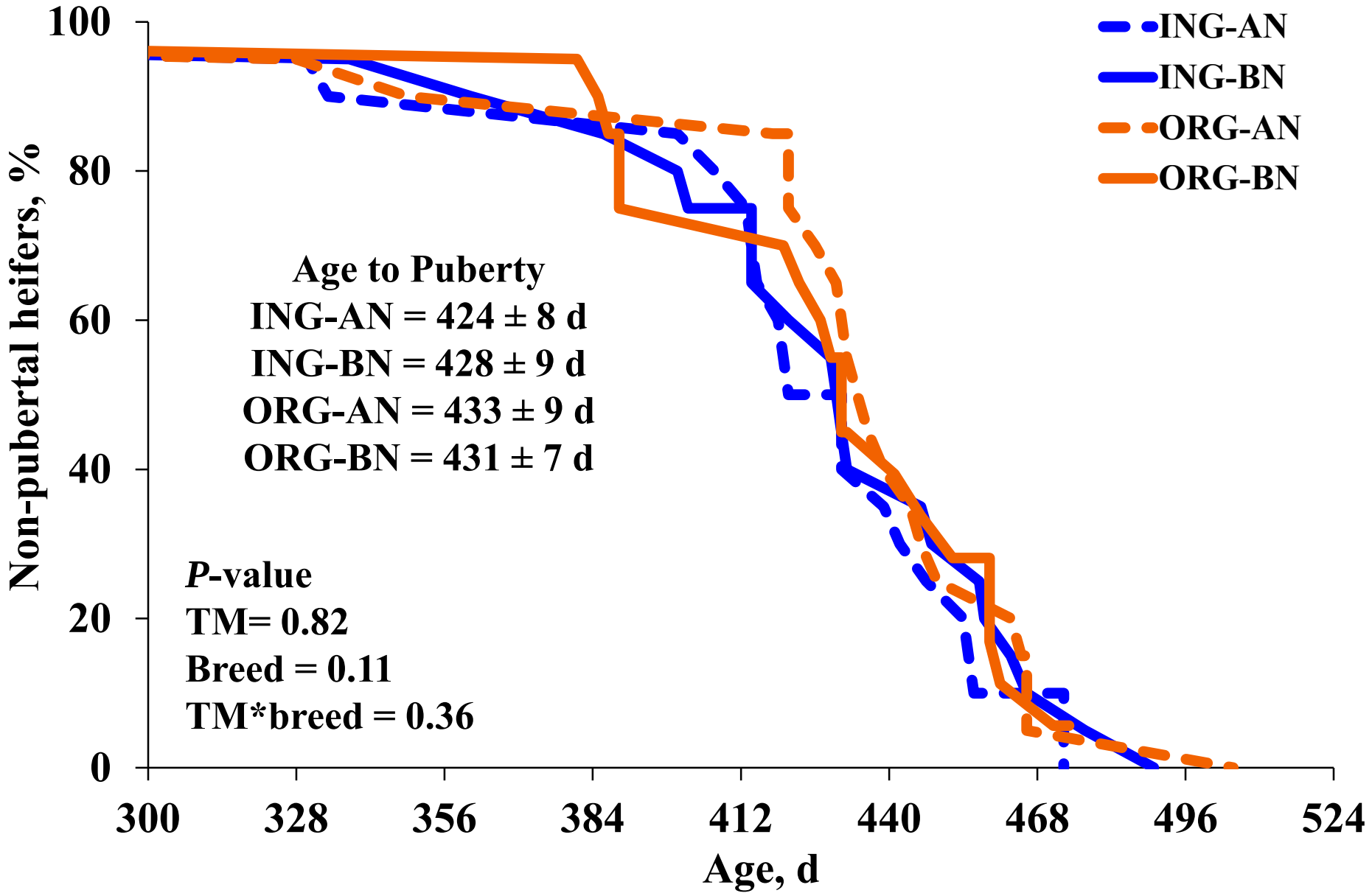
Physical Characteristics of Year 1 Heifers at End of 168 d Development Period

	Trace mineral (TM) × Breed (B)					*P*-value		
Variable	AN-ING	BN-ING	AN-ORG	BN-ORG	SEM	TM	B	TM × B
Heifers, *n*	20	20	20	20				
Age, d	401	401	402	407	5	0.45	0.60	0.54
BW, lb	714	730	737	759	15	0.13	0.26	0.83
Development ADG, lb/d	1.43	1.43	1.41	1.52	0.07	0.49	0.31	0.48
BCS	5.4	5.4	5.4	5.5	0.1	0.38	0.56	0.77
HH, cm	115.3	119.2	116.1	120.0	0.9	0.39	**< 0.01**	1.00

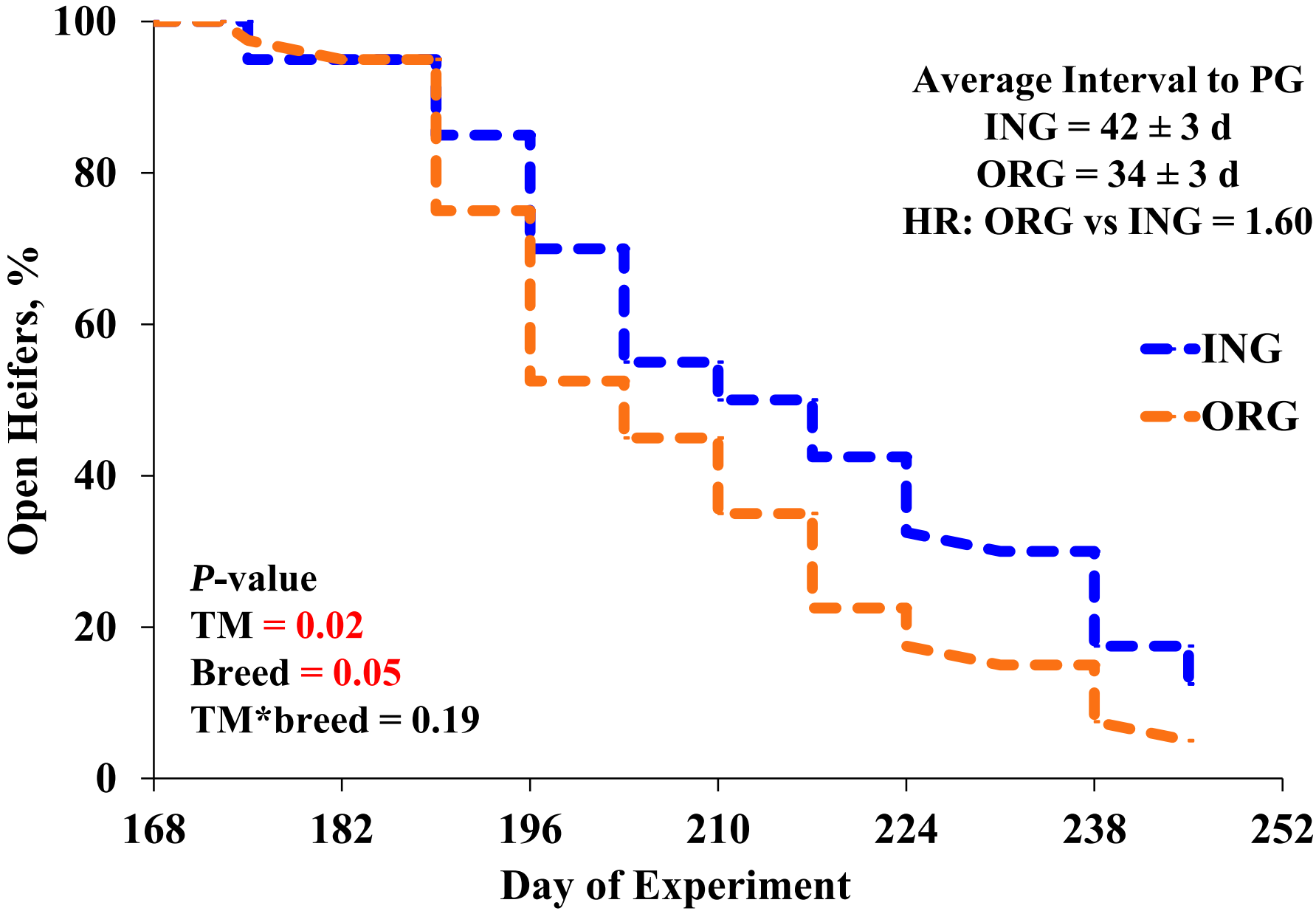
Physical Characteristics of Year 1 Heifers at Initiation 72 d Breeding Season

	Trace mineral (TM) × Breed (B)					*P*-value		
Variable	AN-ING	BN-ING	AN-ORG	BN-ORG	SEM	TM	B	TM × B
Heifers, *n*	20	20	20	20				
RTS, (1-5)	2.8	3.2	3.0	3.6	0.2	**0.09**	**< 0.01**	0.54
Pelvic Area, cm^2	353	375	380	401	9	**< 0.01**	**0.02**	0.97
Pubertal, *n* (%)	4/20 (20)	4/20 (20)	2/20 (10)	3/20 (15)	--	0.36	0.71	0.71

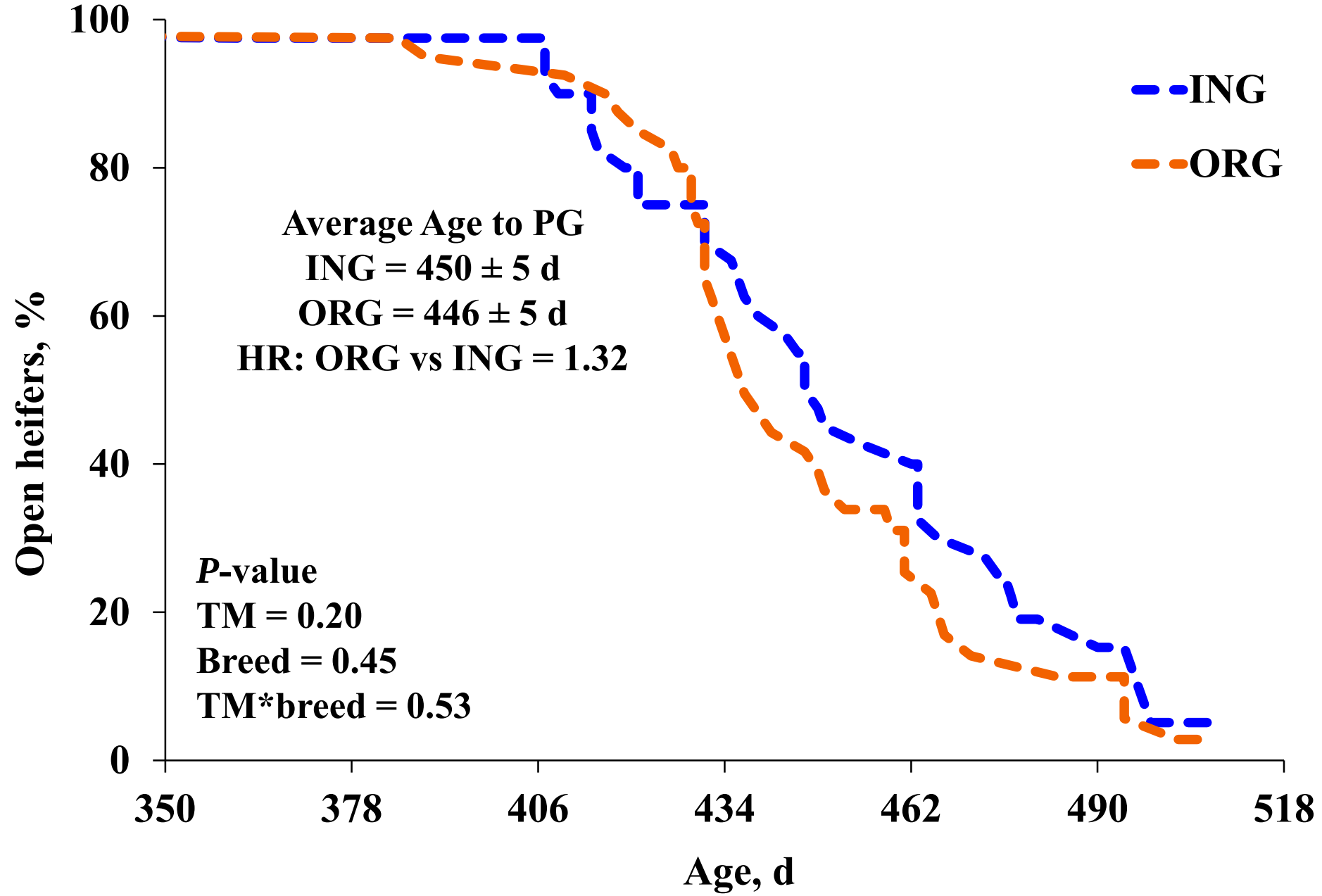
Year 1 Effect of TM source × Breed on Age to Puberty



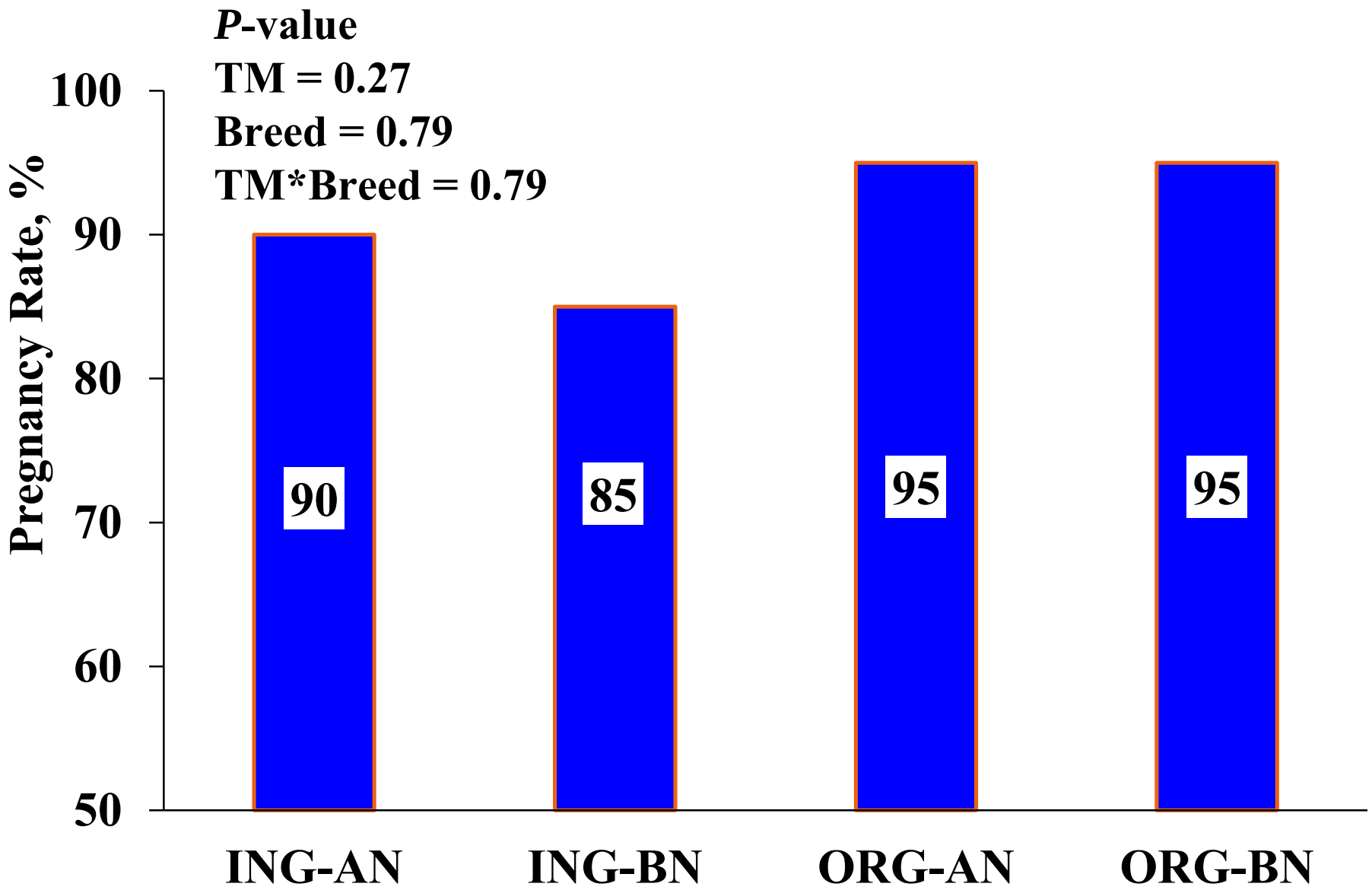
Effect of TM Source on Year 1 Interval to Pregnancy

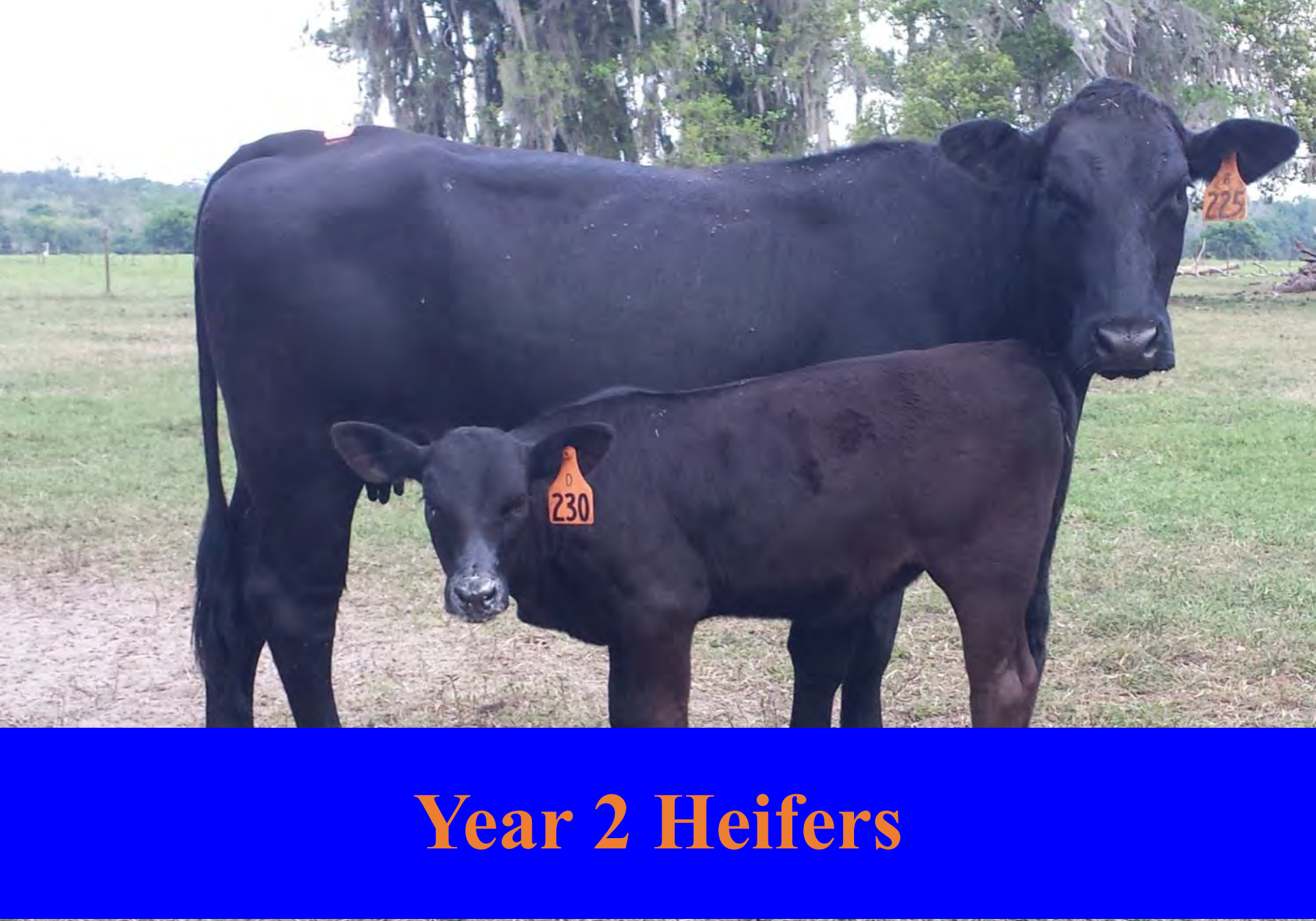


Effect of TM Source on Year 1 Age to Pregnancy



Effect of TM Source × Breed on Heifer Final Pregnancy Rate





Year 2 Heifers

Physical Characteristics of Year 2 Heifers at Initiation of 168 d Development Period

	TM × breed (B)					*P*-value		
Variable	ING-AN	ING-BN	ORG-AN	ORG-BN	SEM	TM	B	TM × B
n	16	15	14	16				
Age, d	245	243	238	231	4	**0.03**	0.28	0.52
BW, lb	476	525	474	523	13.7	0.91	**0.001**	1.00
BCS	4.4	4.7	4.3	4.6	0.08	0.40	**< 0.001**	0.56
HH, cm	106.1	112.9	107.0	111.0	0.82	0.55	**< 0.001**	0.10

Physical Characteristics of Year 2 Heifers at End of 168 d Development Period

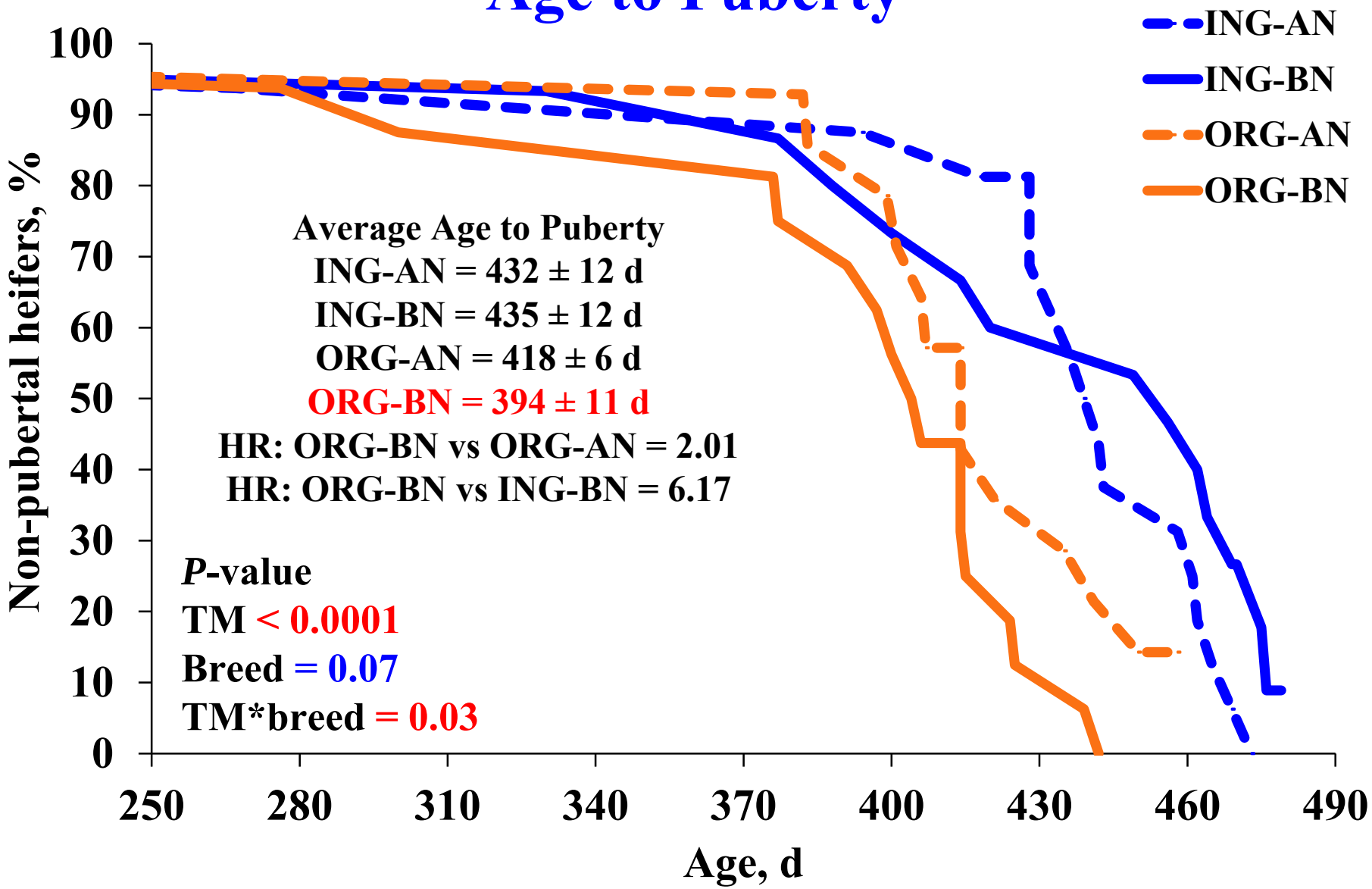
	Trace mineral (TM) × breed (B)					*P*-value		
Variable	ING-AN	ING-BN	ORG-AN	ORG-BN	SEM	TM	B	TM × B
Heifers, *n*	16	15	14	16				
Age, d	413	411	406	399	4	**0.03**	0.28	0.52
BW, lb	675	770	695	772	17.6	0.55	**< 0.01**	0.66
Development ADG, lb/d	1.19	1.46	1.28	1.48	0.07	0.34	**< 0.01**	0.48
BCS	5.0	5.6	5.2	5.6	0.1	0.51	**< 0.01**	0.36
HH, cm	117.4	124.2	117.6	121.6	0.9	0.19	**< 0.01**	0.15

Physical Characteristics of Year 2 Heifers at Initiation of 71 d Breeding Season

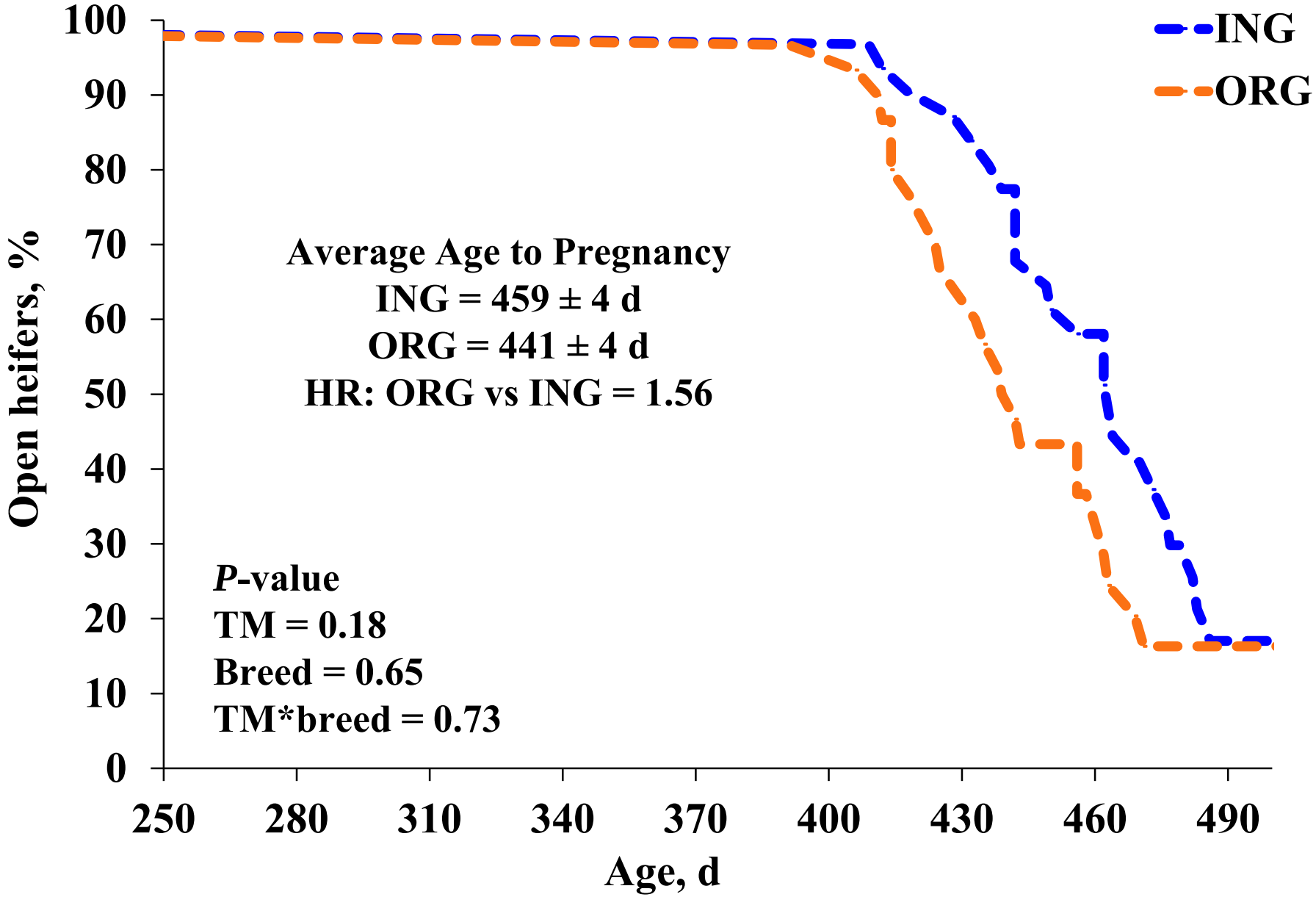
	Trace mineral (TM) × breed (B)					*P*-value		
Variable	ING-AN	ING-BN	ORG-AN	ORG-BN	SEM	TM	B	TM × B
Heifers, *n*	16	15	14	16				
RTS[1], (1-5)	2.9	3.4	3.6	3.6	0.3	0.16	0.40	0.38
Pelvic Area, cm	444	481	440	481	11.3	0.86	**0.001**	0.87
Pubertal, *n* (%)	2/16 (26)	5/15 (33)	**7/14 (50)**	**7/16 (44)**	--	**0.05**	0.40	0.21

[1]**RTS (1-5);** 1 = no palpable structures; 3 = slight uterine tone, 8-10 mm follicles present; 5 = good uterine tone, CL present (Anderson et al., 1991. Agri-Practice)

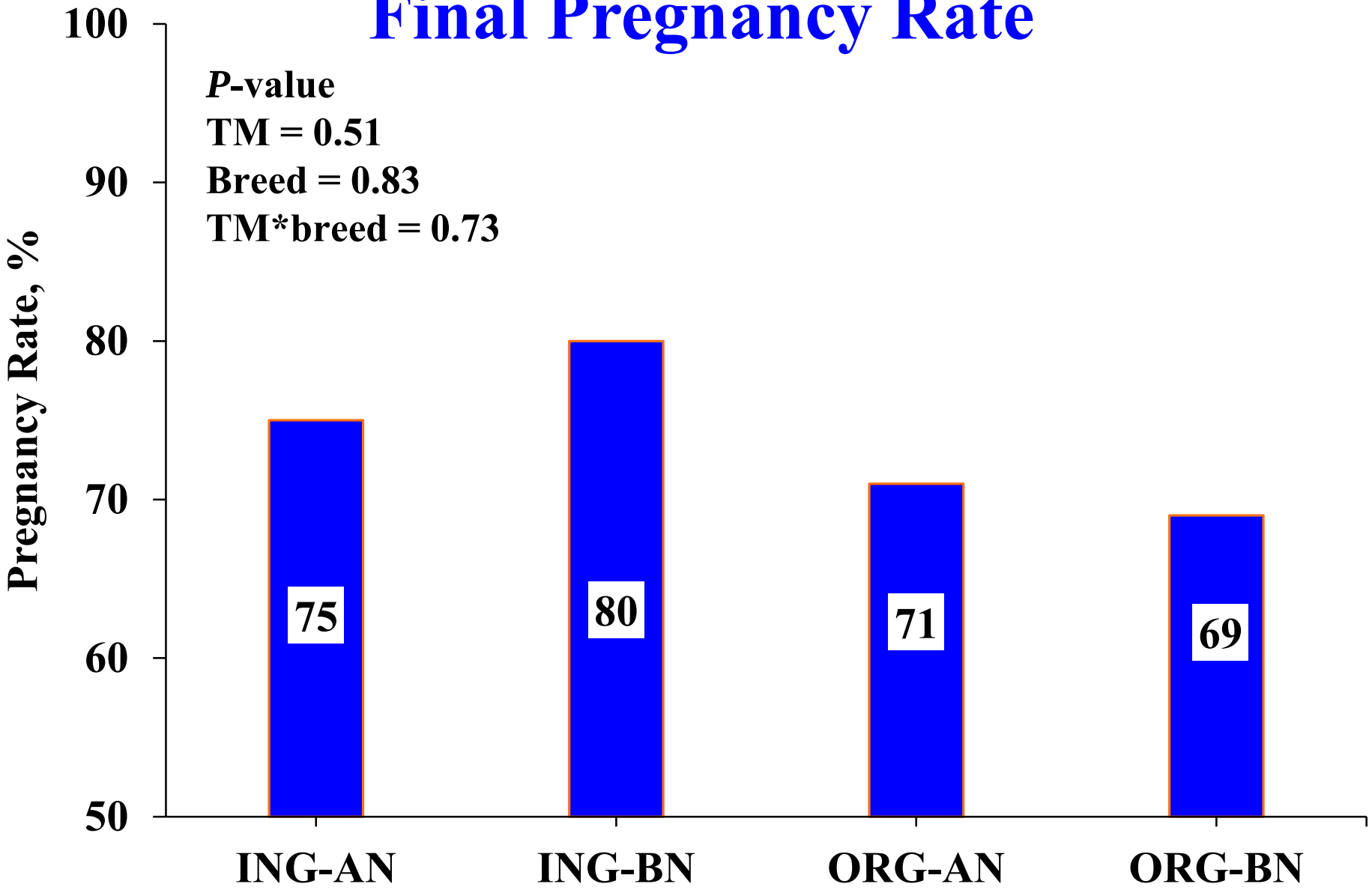
Effect of TM source × Breed on Age to Puberty



Effect of TM source on Age to Pregnancy



Effect of TM Source × Breed on Heifer Final Pregnancy Rate



Summary

- **TM Source × Breed:** decreased age to puberty
  - ORG-BN pubertal 24 d earlier ORG-AN & 41 d earlier ING-BN
- **TM Source**
  - ORG greater ING
    - More heifers pubertal at start of breeding
  - No effect final pregnancy rate
  - Decreased age to puberty & pregnancy
    - ORG pubertal 29 d younger than ING
    - ORG pregnant 18 d younger than ING (not significant)

Summary

- **Breed**
  - Brangus greater Angus
    - Pelvic area at start of breeding
    - BW & BCS all of breeding
  - No effect final pregnancy rate
  - Decreased age to puberty
    - Brangus pubertal 13 d younger than Angus

Conclusions

- TM source has variable/inconsistent effects on performance
- Breed consistently influences performance traits
  Brangus greater BW, BCS, & Pelvic area
- Decreased age to puberty in ORG heifers may hasten the time to pregnancy
- More research needed with larger sample sizes
  - Confirm effect on performance & reproduction
  - Compare timing of supplementation initiation

- **Study effects of prenatal & postnatal TM source on bull sexual development**
  - **Puberty**
  - **Sexual maturity**

Methods & Materials

- Total of 32 bulls; *n* = 8 bulls/treatment
- Every 2 weeks
  - BW, BCS, & scrotal circumference (SC) measured
  - BSE conducted once SC ≥ 26 cm
  - Semen evaluated
    - Concentration – Hemocytometer
    - Gross motility (0 - 4, 0 = none, 1 = poor, 2 = fair, 3 = good, 4 = very good)
    - Individual motility
    - Morphology – normal, primary, & secondary abnormalities
- Liver biopsy (*n* = 4 bulls/treatment) for TM analysis every 56 d

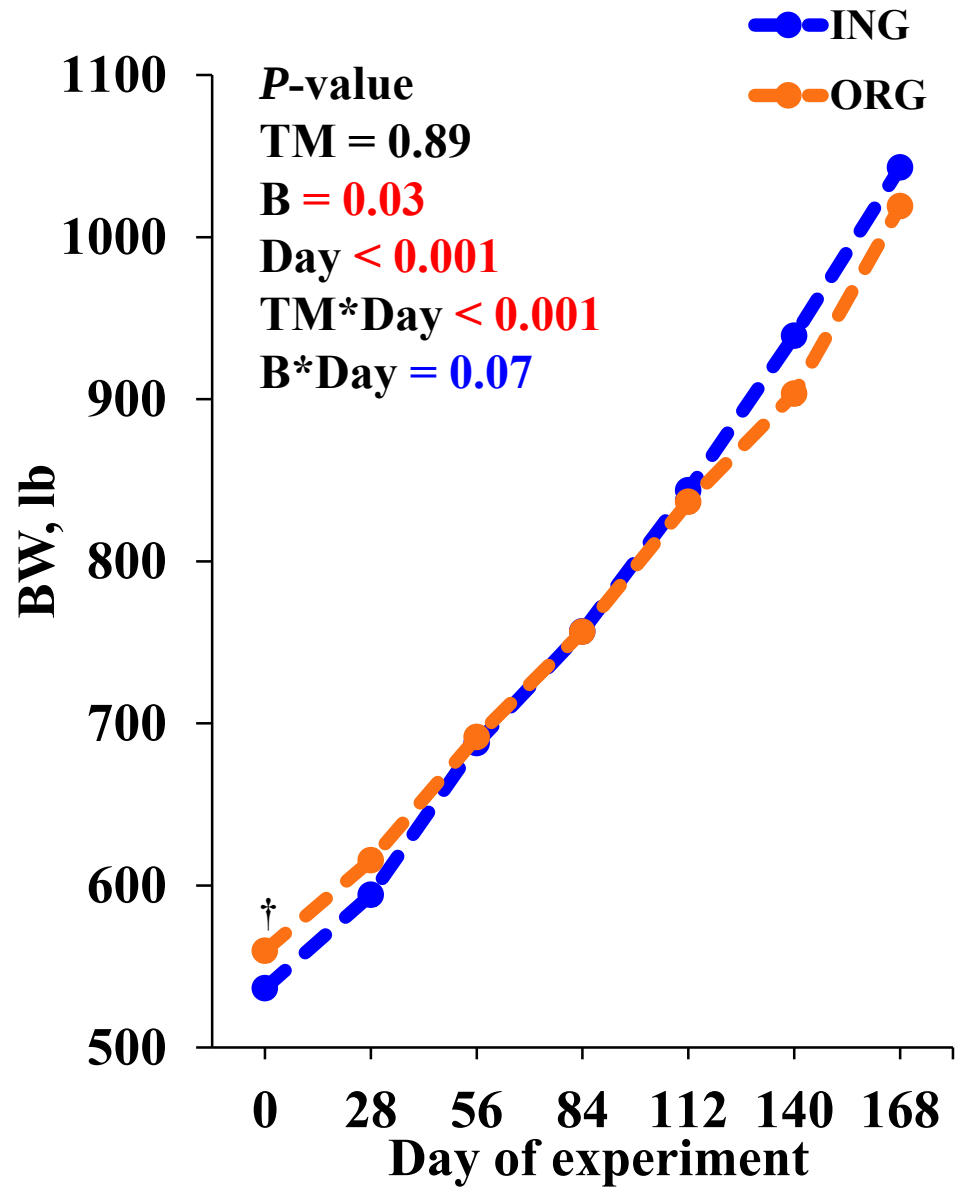
Methods & Materials

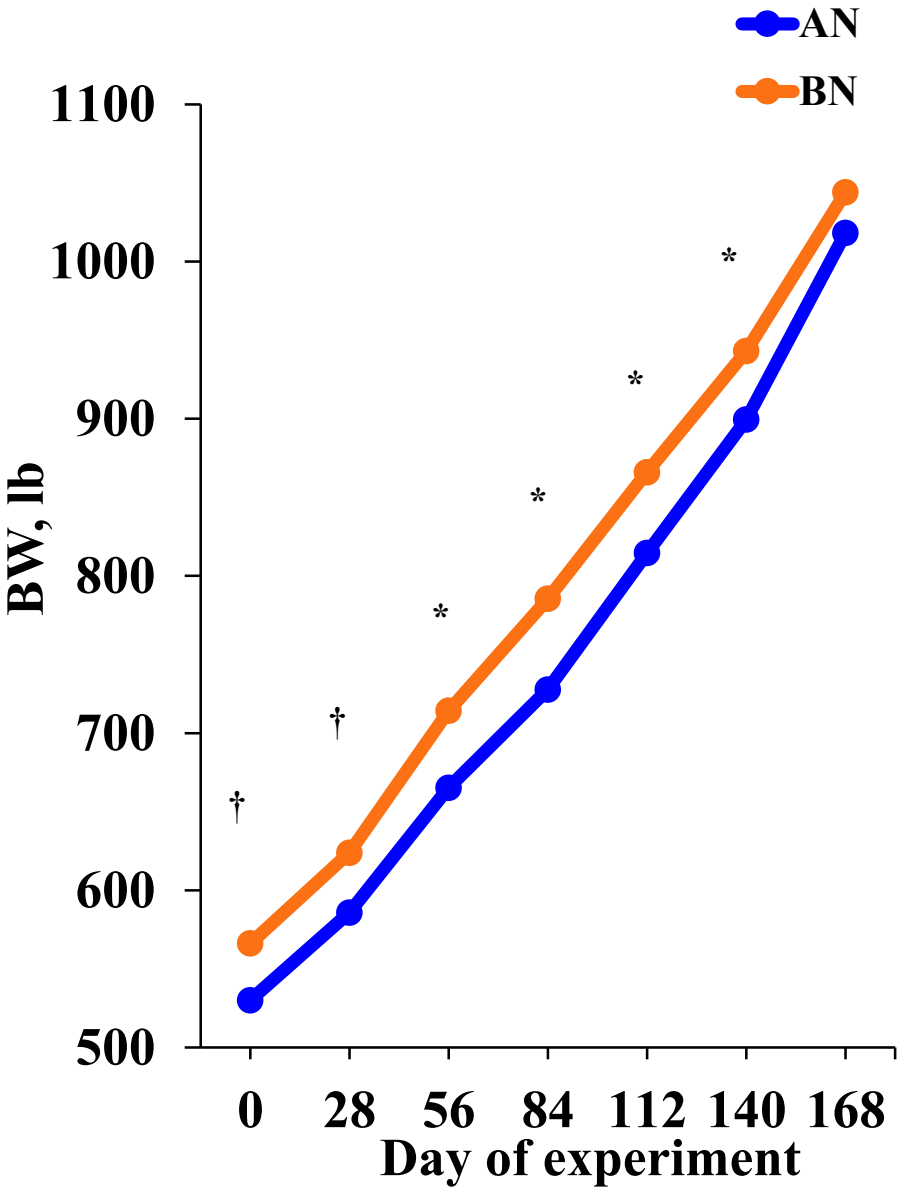
- Puberty = ejaculate ≥ 50 x 10^6 cells/mL & ≥ 10% motility
- Sexual Maturity = based on *Theriogenology* guidelines
    - ≥70% normal sperm
    - ≥ 30% motility
    - SC passed for age
    - Passed 2 consecutive BSE

Bull Physical Characteristics at Experiment Initiation

	Trace mineral (TM) × breed (B)					*P*-value		
Variable	ING-AN	ING-BN	ORG-AN	ORG-BN	SEM	TM	B	TM × B
n	8	8	8	8				
Age, d	252	241	236	234	4	**0.01**	0.11	0.26
BW, lb	516	573	560	573	15	0.14	**0.03**	0.14
BCS	4.7	4.6	4.9	5.0	0.1	**< 0.01**	1.00	0.15
HH, cm	110.2	117.0	111.6	115.6	1.1	1.00	**< 0.01**	0.20
SC, cm	22.9	23.8	22.2	22.9	0.7	0.27	0.23	0.89

Effect of TM Source & Breed on Bull BW

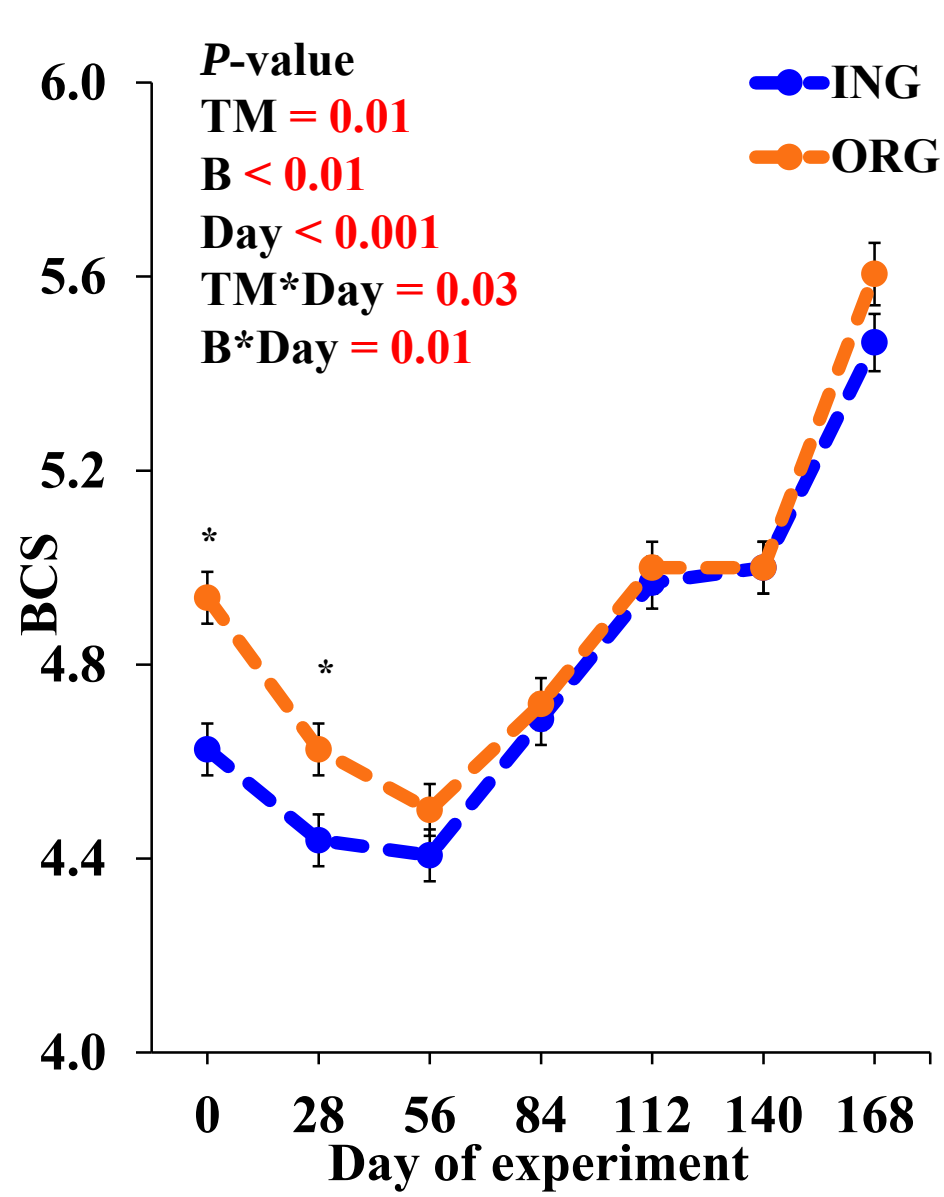


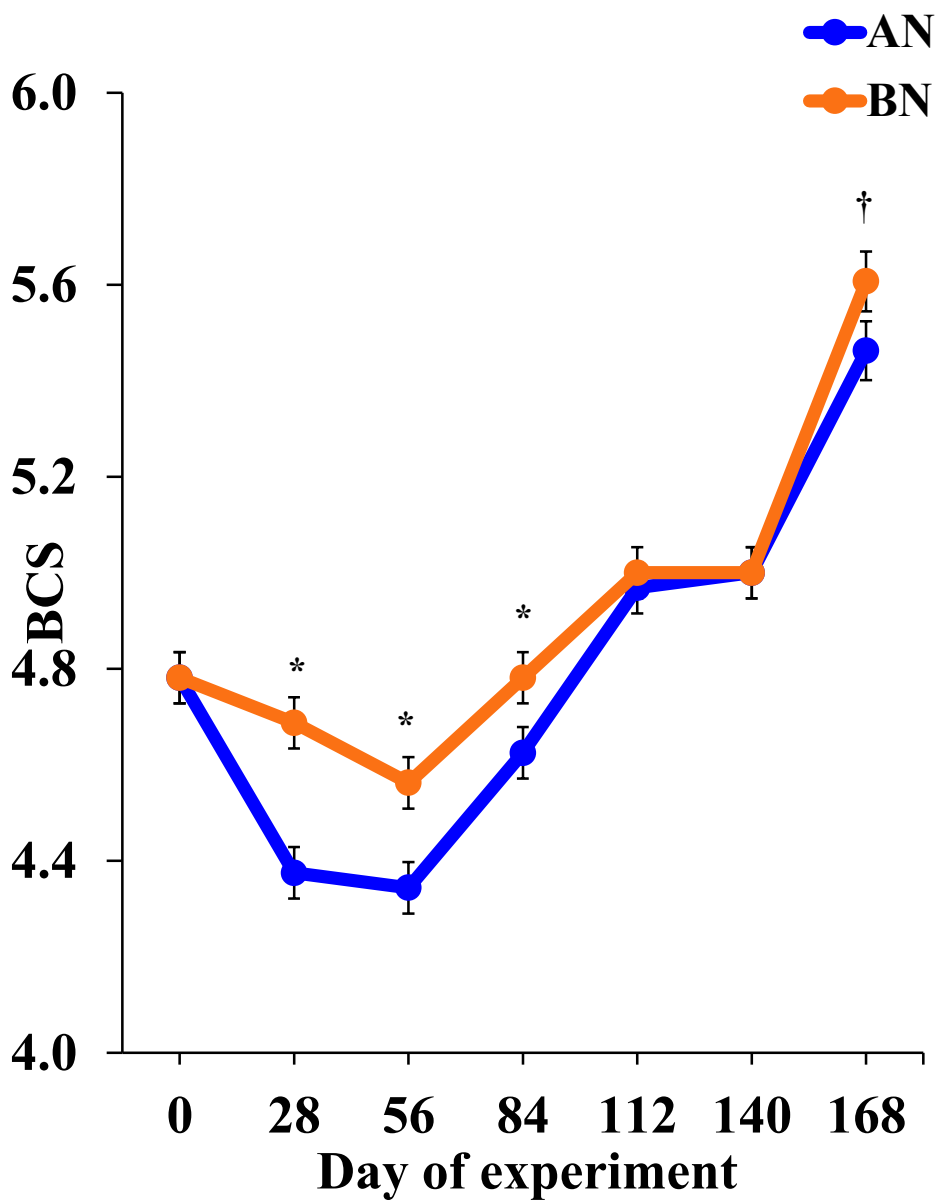


*= Means within day differ, $P \leq 0.05$

† = Means within day differ, $P \leq 0.10$

Effect of TM Source & Breed on Bull BCS



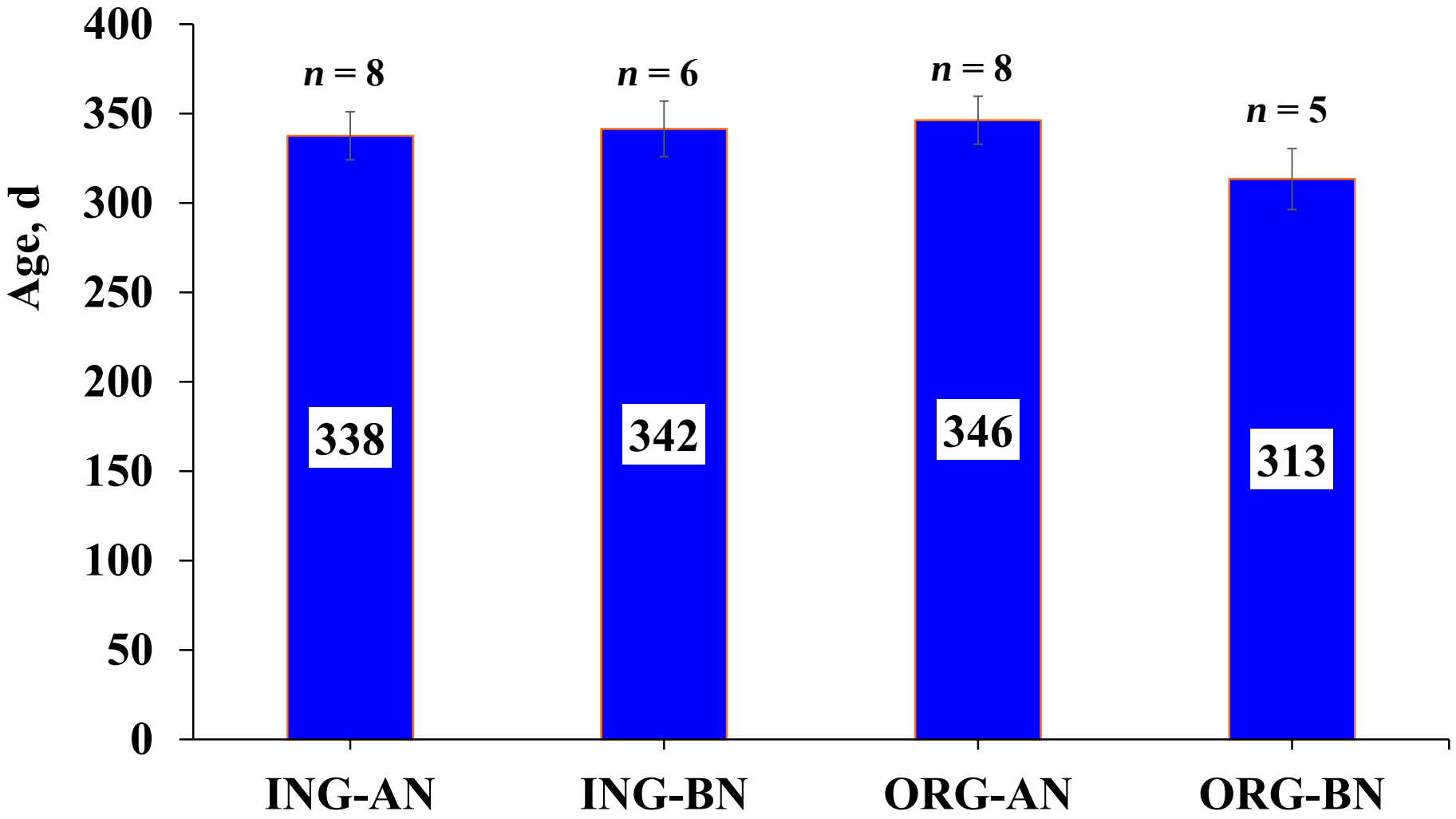


*= Means within day differ, $P \leq 0.05$

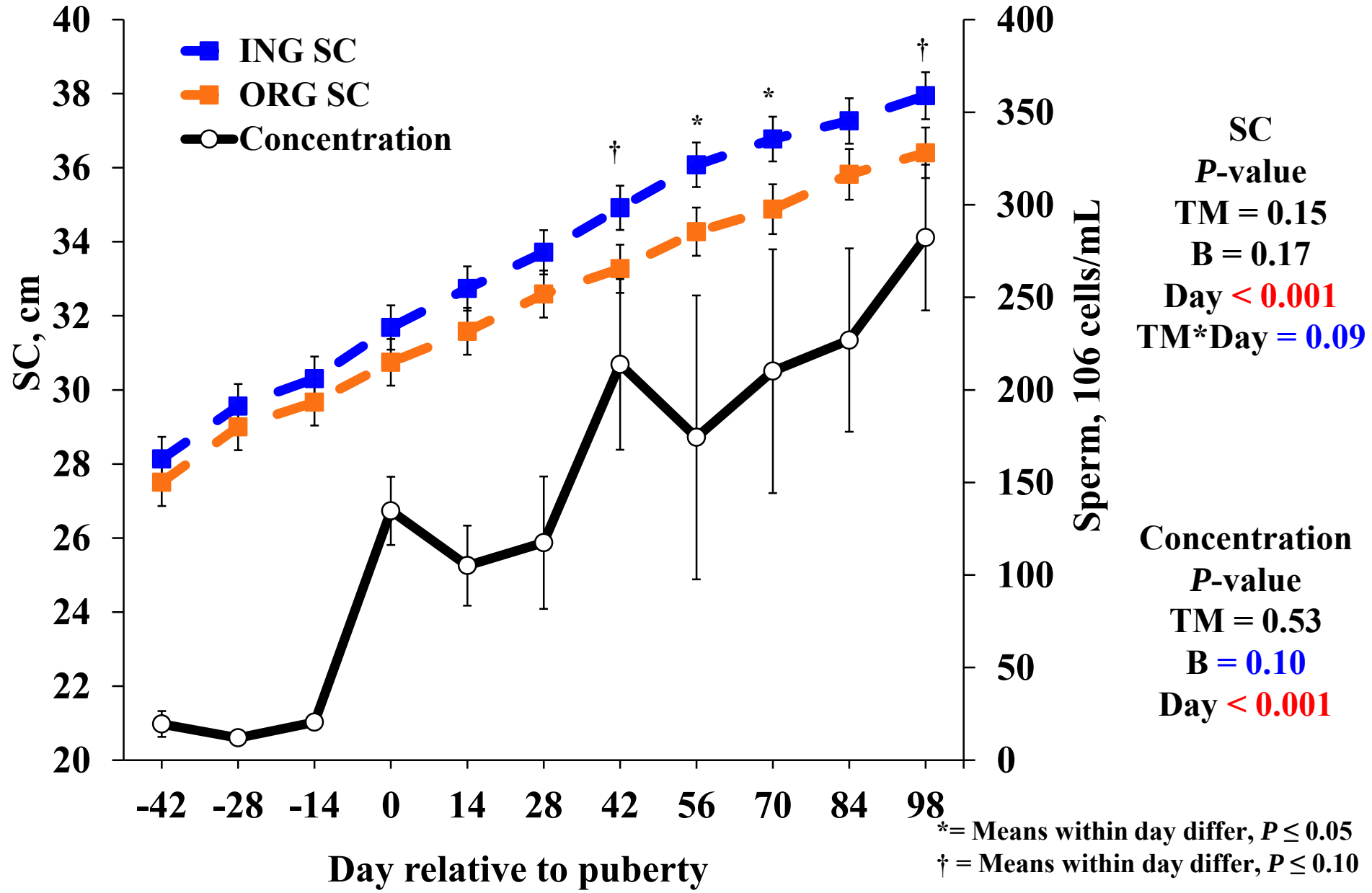
† = Means within day differ, $P \leq 0.10$

Effect of TM Source & Breed on Bull Age at Puberty

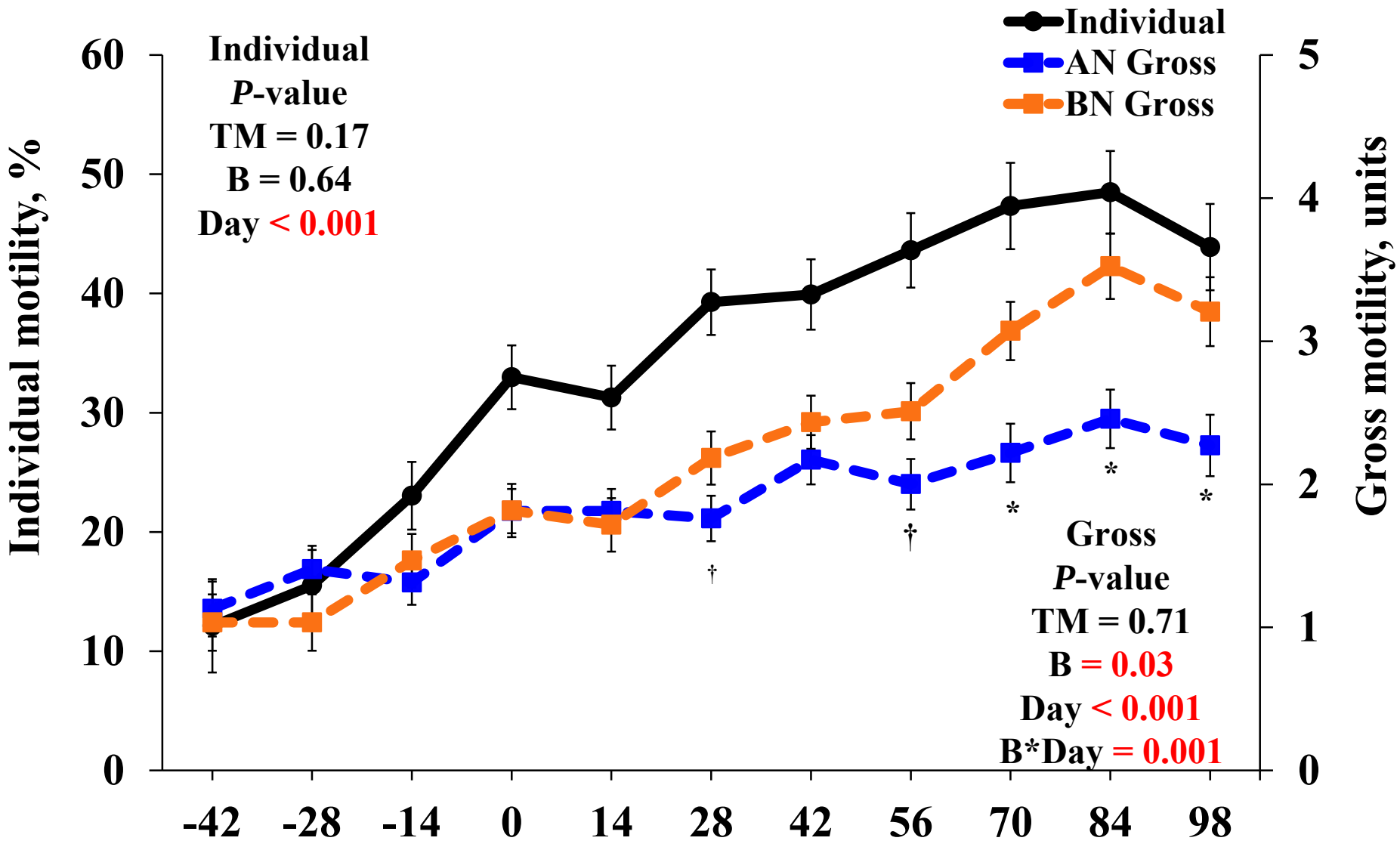
P-value
TM = 0.52
B = 0.34
TM*B = 0.23



Effect of TM Source & Day Relative to Puberty on Bull SC & Sperm Concentration



Effect of Breed & Day Relative to Puberty on Sperm Motility



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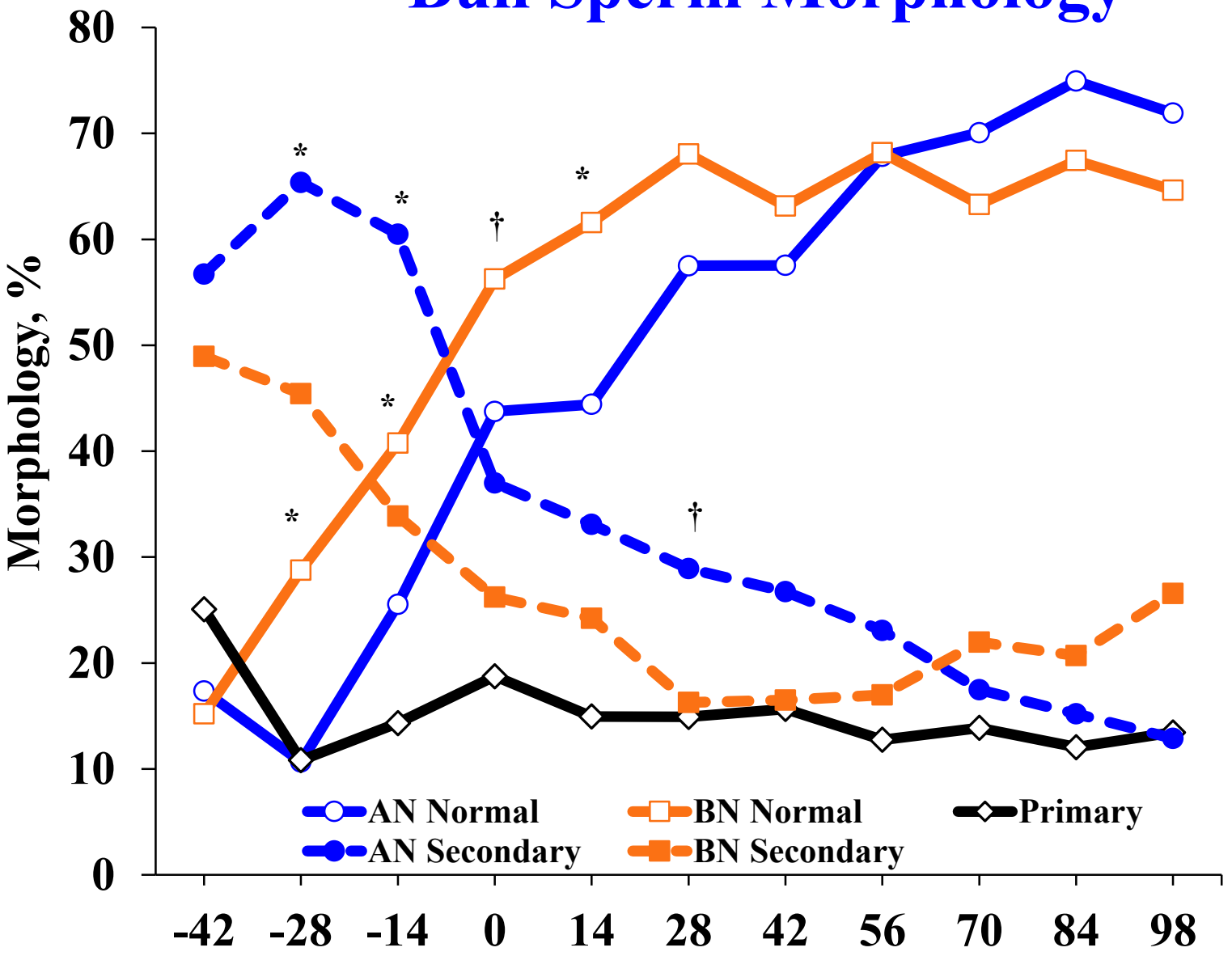
† = Means within day differ, $P \leq 0.10$

Gross motility measured from 0 to 4

Effect of Breed & Day Relative to Puberty on Bull Sperm Morphology



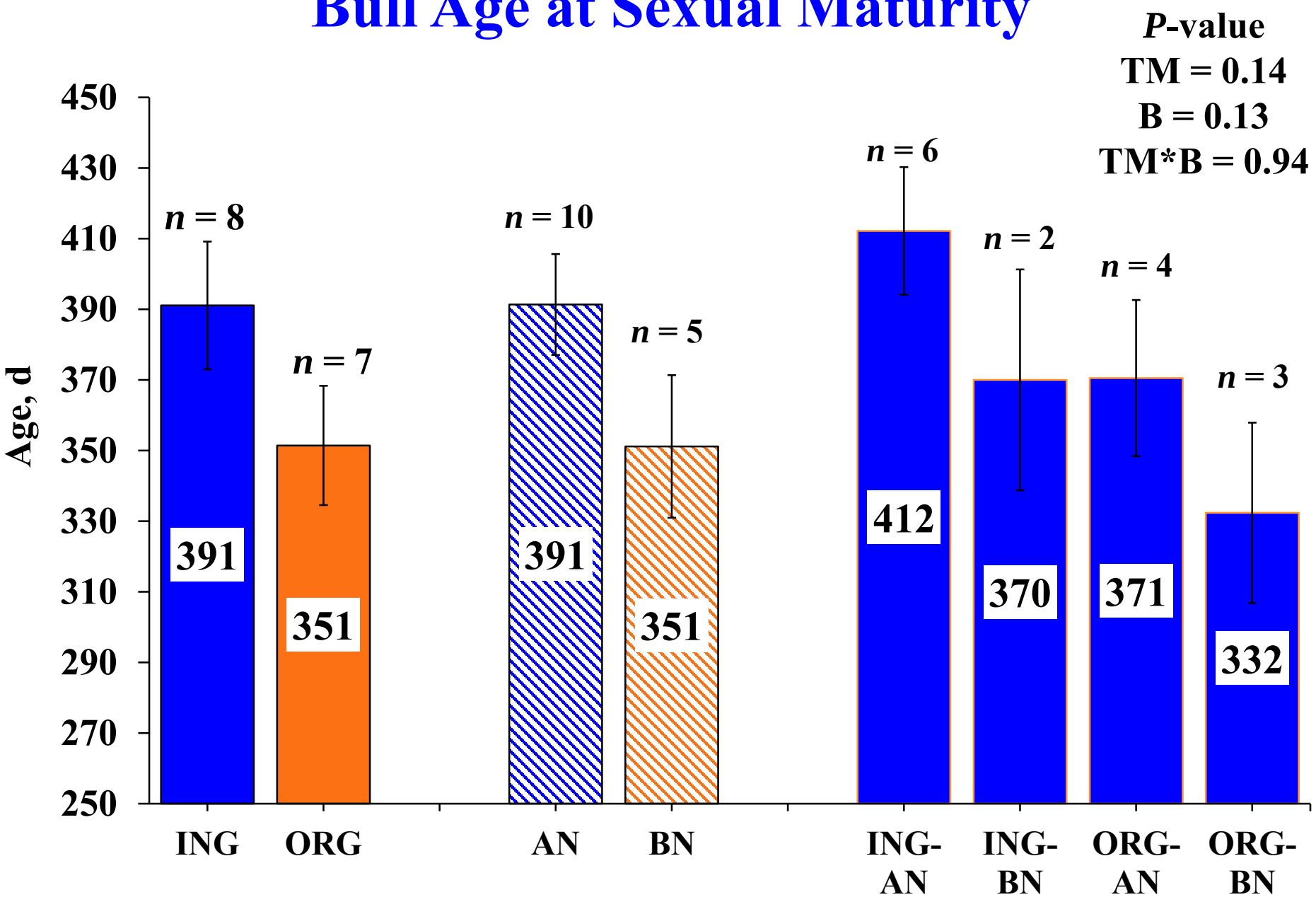
Normal
SEM = 5.8 %
P-value
TM = 0.07
B = 0.29
Day < 0.001
B*Day = 0.05

Primary
SEM = 2.9 %
P-value
TM = 0.24
B = 0.38
Day = 0.07

Secondary
SEM = 5.7
P-value
TM = 0.19
B = 0.07
Day < 0.001
B*Day = 0.02

*= Means within day differ, $P \leq 0.05$
† = Means within day differ, $P \leq 0.10$

Effect of TM Source & Breed on Bull Age at Sexual Maturity



Bull Seminal Characteristics at Experimental Endpoint[1]

	Trace mineral (TM) × breed (B)					*P*-value		
Variable	ING-AN	ING-BN	ORG-AN	ORG-BN	SEM	TM	B	TM × B
SC, cm	34.9	36.4	34.5	33.0	1.09	**0.10**	1.00	0.18
Sperm, 10^6 cells/mL	156.0	540.3	108.4	119.6	98.35	**0.03**	**0.06**	**0.07**
Gross Motility[2], units	2.3	2.5	2.1	2.0	0.32	0.33	0.84	0.56
Individual motility, %	37.5	32.9	48.8	40.0	5.26	**0.09**	0.21	0.70
Normal sperm, %	66.1	60.0	63.5	68.9	6.38	0.63	0.95	0.38
Primary abnormalities, %	16.0	19.2	17.6	15.7	6.23	0.88	0.92	0.69
Secondary abnormalities, %	17.9	20.8	18.9	15.4	4.53	0.63	0.96	0.49

[1]Experimental endpoint defined as sexual maturity (if bull reached) or d 196 of experiment

[2]Gross motility measured on scale of 0-4.

Summary

- **TM source × breed**
  - Tended affect endpoint sperm concentration
    - ING-BN greatest concentration – due to 1 bull
- **TM Source**
  - No effect bull performance
  - ING greater SC post puberty
  - No effect seminal traits relative to puberty & sexual maturity
  - ORG tended greater individual motility at experimental endpoint
  - No effect age at puberty
  - Numerically decreased age at sexual maturity in ORG bulls by 40 d

Summary

- **Breed**
  - Affected endpoint performance: BN > AN for BW, BCS, & HH
  - Liver TM concentrations: BN > AN for Cu, Mn, & Se
  - Seminal traits prior to puberty
    - BN > AN Normal sperm
    - AN > BN Secondary abnormalities
  - Post-puberty gross motility: BN > AN

Discussion

- Larger sample sizes to confirm effect of TM source on age at sexual maturity
  - ORG TM source may aid development of earlier maturing bulls
- More research needed to determine if fertility differences exist between TM sources

Overall Conclusions

- ORG TM may hasten onset of
  - Puberty & age to pregnancy in heifers
  - Age at sexual maturity in bulls
- Studies are needed to determine if timing of TM supplementation affects calf growth and sexual development
- Additional investigations into effects of TM source on endocrine and hormonal parameters could elucidate mechanisms behind differences in sexual development based on TM source

Questions