

Early pair housing increases solid feed intake and weight gains in dairy calves

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1 **Running head:** Pair housing at birth increases feed intake and weight gains

2 **Interpretive summary**

3 **Early pair housing increases solid feed intake and weight gains in dairy calves**

4 Costa et al. Page 000-000. Milk-fed calves are typically housed individually, but social housing may
5 increase calf feed intake. The aim of this study was to assess the effects of early (6d of age) and late
6 (43d of age) pairing on feeding behavior and weight gains in Holstein dairy calves. Calves paired
7 soon after birth had the highest intake of solid feed and the highest body weight gains in comparison
8 with late paired and individually housed calves. These results indicate that calves can benefit from
9 early social housing.

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12 **EARLY PAIR HOUSING INCREASES SOLID FEED INTAKE AND WEIGHT GAINS IN**
13 **DAIRY CALVES**

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21

22 **ABSTRACT**

23 Dairy calves have traditionally been kept in individual pens throughout the milk-feeding period.
24 Social rearing is associated with increased solid feed intake and hence higher weight gains before
25 and after weaning. Little is known about the effect of the age at which social housing begins. The
26 aim of this study was to assess the effects of early versus late pairing on feeding behavior and weight
27 gain before and after weaning. Holstein bull calves were reared individually (n=8 calves), or paired
28 with another calf at 6 ± 3 d (n=8 pairs) or 43 ± 3 d of age (n=8 pairs). All calves were fed 8 L of
29 milk/d for 4 wk, 6 L/d from 4 to 7 wk and then milk was reduced by 20%/d until calves were
30 completely weaned at 8 wk of age. Calves were provided *ad libitum* access to calf starter and a total
31 mixed ration (TMR). Body weight and feed intake were measured weekly from 3 to 10 wk of
32 age. Intake of calf starter was significantly higher for the early-paired calves than for individually-
33 reared and late-paired calves throughout the experimental period. At 10 wk of age, starter dry matter
34 intake (DMI) averaged 2.20 ± 0.22 kg/d, 1.09 ± 0.25 kg/d and 1.26 ± 0.33 kg/d for early pair, late
35 pair and individually housed calves, respectively. Intake of TMR did not differ among treatments,
36 TMR dry matter intake (averaged 3.27 ± 0.72 kg/d, 3.08 ± 0.46 kg/d, and 2.89 ± 0.54 kg/d for the
37 same three treatments). Calves in the early pair treatment also showed significantly higher average
38 daily gain (ADG) over the experimental period (0.89 ± 0.04 kg/d versus 0.76 ± 0.04 kg/d and $0.73 \pm$
39 0.04 kg/d for the early paired, individual and late-paired calves, respectively). These results indicate
40 that social housing soon after birth can increase weight gains and intake of solid feed.

41

42 **Key words:** weaning; animal welfare; forage; social facilitation; social learning; Holstein

43

INTRODUCTION

44

45

46 Dairy farms often separate calves from their dams within 24 h after birth and then house calves
47 individually (USDA, 2008; Vasseur et al., 2010; Hötzel et al., 2014). Housing milk-fed calves in
48 pairs or groups is increasing in popularity, in part due to the potential of reducing labor requirements
49 per head. Social housing can also provide animal welfare benefits as it allows calves to perform
50 social behaviors and can provide calves more useable space (Jensen et al., 1997; Faerevik et al.,
51 2006).

52 Calves that consume little solid feed before weaning are more likely to experience poor growth
53 and prolonged hunger after weaning, until intake of solid feed meets their requirements for
54 maintenance and growth (Jasper and Weary, 2002; de Passillé et al., 2011). Encouraging solid
55 intakes early in life can help smooth the transition from milk to solid feed at weaning.

56 Social housing of dairy calves has been shown to reduce behavioral responses to weaning and
57 improve performance when mixed with a larger group after weaning (de Paula Vieira et al., 2012).
58 Housing dairy calves in a social group also reduces food neophobia (Costa et al., 2014). Group-
59 housed calves have increased weaning weights compared with individually housed calves, likely due
60 to increased DMI during the pre-weaning period (Chua et al., 2002; Xicatto et al., 2002; de Paula
61 Vieira et al., 2010, Bernal-Rigoli et al., 2012). Increased DMI is often attributed to social learning
62 and social facilitation during feeding (Launchbaugh and Howery, 2005).

63 On some farms calves are housed individually for the first weeks of life and then paired or
64 moved to a group around the time of weaning (Staněk et al., 2014), but it is unknown when contact
65 with peers is necessary to achieve the benefit of increased early intake of solids. The aim of this
66 study was to assess the effects of early and late pairing on feeding behavior and weight gain before
67 and after weaning. We predicted that calves paired early in life (at 6 d) would begin eating solids at a

68 younger age, consume more solids throughout the pre-weaning period, and gain more BW in
69 comparison with calves housed individually or calves paired later in life (6 weeks of age).

70

71 **MATERIALS AND METHODS**

72

73 This experiment was carried out between April and December of 2013 at The University of
74 British Columbia's (UBC) Dairy Education and Research Centre, located in Agassiz, British
75 Columbia, Canada (49°N, 121°W). All procedures carried out in this study were approved by the
76 UBC Animal Ethics Committee (AUP A12-0337). The animals were cared for according to the
77 guidelines outlined by the Canadian Council of Animal Care (2009).

78

79 ***General Methodology and Treatments***

80 Forty Holstein bull calves were enrolled at birth. Calves were separated from their dam and fed at
81 least 4L of colostrum (with > 50 g/L of IgG) by bottle within 6 h of birth. Blood samples were
82 collected from the jugular vein 24 h after the first feeding of colostrum and serum was analyzed
83 using a Reichert AR 200 Digital Handheld Refractometer (Reichert, Depew, USA). Only calves with
84 serum protein >5.5 g/dL were kept in the trial. After birth, calves were weighed (mean 43.5 ± 5.1 kg
85 BW) and moved to individual pens with no visual contact with any other calf and were bottle-fed up
86 to 8 L of whole milk daily.

87 At 6 ± 3 d of age calves were assigned to one of three treatments: individual (n=8), early pair
88 (n=8 pairs) or late pair (n=8 pair). Assignment was random within blocks of 5 calves, within the
89 constraint that calves closest in age were assigned to pair treatments. Individually-reared calves were
90 kept in individual pens (1.2 m × 2 m) on sawdust bedding, with no visual contact with any other calf
91 for the entire length of the experiment (70 d). For early-paired calves, 2 calves were paired at 6 ± 3
92 days of age by having the barrier to the neighboring pen removed to create a double pen. For late-

93 paired calves, the individual housing continued until the age of 43 ± 3 d, 14 d before weaning. In
94 both pair housing treatments, calves were provided twice the area ($2.4 \text{ m} \times 2.0 \text{ m}$), milk bottle
95 holders, water and solid feed buckets in the same pen system as the individually raised calves.

96

97 ***Milk delivery, solid feeding and weaning***

98 All calves were bottle-fed pasteurized whole milk twice per day. From 0 d to 28 d of age calves
99 in all treatments received 8 L/d of whole pasteurized milk, divided in 2 feedings, delivered at 0800h
100 and 1630h. From d 29 to d 49 calves were fed 6 L/d, fed as described above. From d 50 to d 54 milk
101 was reduced by 20%/d for 5 days until calves were completely weaned at d 55. Calves were enrolled
102 in the experiment until d 70. All calves had ad libitum access to water, TMR (shown as % of DM,
103 consisting of 26.1 % corn silage, 14.8 % grass silage, 10 % alfalfa hay and 49 % concentrated mix;
104 which was on average 49.1 ± 1.5 % DM; chemical composition shown as % of DM, CP 17 %, NDF
105 32 %, ADF 20 %) and calf starter (Hi-Pro Medicated Calf Starter, Chilliwack, BC, Canada with an
106 overall DM of 89.5%; chemical composition shown as % of DM, 90% DM; CP 21%, NDF 19%,
107 ADF 11%; medicated with a coccidiostat [50 mg/kg of Lasalocid Sodium]) during the experimental
108 period. Samples of the feed were taken prior to feeding bi-weekly and frozen, at the end of the
109 experiment the samples were sent to A&L Canada Laboratories Inc. (London, ON). Samples for
110 nutrient and DM analysis were oven dried at 55°C for 48 h. Dried samples were ground to pass
111 through a 1-mm screen and for analysis of ADF (AOAC International, 2000: method 973.18), NDF
112 with heat-stable α -amylase and sodium sulphite (Van Soest et al., 1991), and CP ($\text{N} \times 6.25$; AOAC
113 International 2000: method 990.03; Leco FP-528 Nitrogen Analyzer, Leco, St. Joseph, MI). Fresh
114 feed and water were delivered daily at approximately 0830h, and feed refusals were removed before
115 the new feed was delivered. Daily (24 h) calf starter and TMR intakes were determined each
116 morning by disappearance.

117

118 ***Performance and health***

119 Calves were weighed and health scored weekly. Individual BW of each calf was recorded and
120 ADG was calculated for the pre-weaning period (3 to 6 wk), the weaning period (6 to 10 wk) and
121 over the whole experimental period (3 to 10 wk). Health checks were performed following de Paula
122 Vieira et al. (2010), which consisted of diarrhea scoring, where 1 = normal feces; 2 = plaques but not
123 watery; 3 = watery and body temperature $< 39.5^{\circ}\text{C}$; 4 = watery and body temperature $\geq 39.5^{\circ}\text{C}$.
124 Calves with a score = 4 were treated with electrolytic solutions (Hydrafeed, EXL Laboratories,
125 Minneapolis, MN, USA), and calves failing to respond to treatment within 2-d were administered a
126 NSAID (Metacam 20 mg/mL, Boehringer Ingelheim, Burlington, Ont., Canada), according to our
127 farm's standard procedure. During the experimental period 3 calves from the early-paired, 3 calves
128 from the late-paired and 1 calf from the individually-reared treatment were treated with NSAID.
129 Clinical examination of respiratory health was also performed. Calves showing nasal discharge and
130 pathological sounds of pulmonary infection during auscultation were classified as ill, and treated
131 with antibiotic drugs (Resflor GOLD[®], Intervet Inc. Roseland, NJ, USA) according to the farm's
132 standard operating procedure. During the experimental period 2 calves from each treatment were
133 treated with antibiotic drugs.

134

135 ***Statistical Analysis***

136 All analyses were performed with SAS (version 9.3; SAS Inst. Inc., Cary, NC) using the pen (i.e.
137 calf or pair) as the experimental unit. Intake of TMR and calf starter were measured daily but
138 averaged to form weekly values for intake per calf per day. Intake of TMR and calf starter are
139 expressed on a DM basis. DMI of TMR and calf starter, total DMI (i.e. TMR + calf starter), ADG
140 and birth BW were considered as dependent variables. Prior to analysis, data were checked for
141 normality using the UNIVARIATE procedure in SAS and probability distribution plots. The effect of
142 treatment on each variable was tested using the MIXED procedure in SAS.

143 For the variables intakes of TMR, calf starter and total DMI the model included treatment, week
144 and the interaction of the week and the treatments. Week was specified as a repeated measure and
145 calf or pair specified as subject, using an autoregressive covariance structure. ADG over each period
146 (pre-weaning, weaning and over the whole experimental period) was calculated and tested in a model
147 that included treatment and calf or pair as a random effect. The PDIFF statement was used to
148 compare the least square means of each combination of treatments, and the p-values were corrected
149 using the Bonferroni correction.

150

151

152

RESULTS

153

154 Intake of TMR was similar across the 3 treatments ($F_{2, 22} = 0.46$; $P = 0.63$; Fig. 1a), but early-
155 paired calves ate more calf starter ($F_{2, 22} = 3.46$; $P = 0.03$; Fig. 1b) and consequently showed higher
156 total DMI ($F_{2, 22} = 10.61$; $P < 0.001$; Fig. 1c) relative to the individual and late pair treatments. Solid
157 feed intake was minimal until calves were 3 wk old. At 6 wk, intake of TMR was not different
158 between treatments ($F_{2, 22} = 1.40$; $P = 0.27$) and averaged 0.17 ± 0.07 kg/d, 0.31 ± 0.07 kg/d, $0.18 \pm$
159 0.06 kg/d, for individually, early pair and late pair housed calves, respectively. Starter intake was
160 similar for the individually-reared and late-paired calves (0.07 ± 0.03 kg/d and 0.05 ± 0.03 kg/d) but
161 higher for the early-paired calves (0.18 ± 0.03 kg/d; $F_{2, 22} = 5.00$; $P = 0.02$). Consumption increased
162 after weaning in all treatments, but this increase was greatest for the early-paired calves. At 10 wk of
163 age, intake of calf starter was higher than the other two treatments ($F_{2, 22} = 4.11$; $P = 0.03$). Calf
164 starter intake averaged 2.20 ± 0.22 kg/d, 1.09 ± 0.25 kg/d and 1.26 ± 0.33 kg/d for early pair, late
165 pair and individually housed calves, respectively. Intake of TMR did not differ among treatments
166 ($F_{2, 22} = 1.18$; $P = 0.33$), TMR intake averaged 3.27 ± 0.72 kg/d, 3.08 ± 0.46 kg/d, and 2.89 ± 0.54
167 kg/d for the same three treatments.

168 Calves in the early pair treatment gained more weight than did the calves in the other 2
169 treatments during the entire experimental period (0.89 ± 0.04 kg/d versus 0.76 ± 0.04 kg/d and $0.73 \pm$
170 0.04 kg/d for the early-paired, individual and late-paired calves, respectively; $F_{2, 22} = 4.87$; $P < 0.01$).
171 ADG was not different between treatments during the pre-weaning period (3 to 6 wk) ($F_{2, 22} = 0.98$;
172 $P = 0.39$; Fig 2a) but early-paired calves had higher ADG ($F_{2, 22} = 4.13$; $P = 0.03$; Fig. 2b) during the
173 weaning period (6 to 10 wk) relative to the individual and late pair treatments.

174

175 **DISCUSSION**

176

177 This study is the first to explore the effects on feed intake of late pairing of calves, in comparison
178 to early pair housing and individual housing. Early pair housing increased calf feed intake and BW.
179 Calves paired soon after birth began to consume solid feed earlier than late-paired and individually
180 housed calves likely contributing to the increased weight gains.

181 The findings of the current study, showing increased intake by socially housed calves, are
182 consistent with earlier work on social versus individual housing (Chua et al., 2002; Xicatto et al.,
183 2002; de Paula Vieira et al., 2010, Bernal-Rigoli et al., 2012). The results of the current study
184 indicate that grouping must occur before 6 wk to provide this benefit. Tapki (2007) compared calves
185 grouped at birth versus at 3 wk of age and found no difference in solid feed intake.

186 The results of the current study are also consistent with previous work showing that early
187 grouping can have an important influence on the development of dairy calves. For example, social
188 housing is associated with cognitive benefits including improved performance in reversal learning
189 and improved object recognition (Gaillard et al., 2014). Duve and Jensen (2012) found that when
190 calves were housed individually for 3 wk and then paired, they performed more social behaviors than
191 calves housed individually with limited social contact throughout the pre-weaning period. Only
192 minor differences were found between calves housed together from birth compared with those paired

193 at 3 wk of life. In combination, these results indicate that the critical phase for grouping occurs
194 sometime between 3 and 6 wk of age, as calves paired at 3wk did not differ from calves paired at
195 birth. Based upon these results our conservative recommendation is to group calves within the first 3
196 wk of life.

197 The early-paired calves in the current study gained weight at a faster rate than did the
198 individually-reared and late-paired calves. This increased ADG can be explained by the greater solid
199 feed intake. Solid feed intakes are likely to be an important determinant of gains, especially when
200 calves are fed limited quantities of milk (see review by Khan et al., 2011). Solid intakes likely
201 became more important to growth in the current study after 4 wk of age, when the milk ration was
202 reduced from 8 L to 6 L. An additional benefit of establishing high solid intakes before weaning is
203 that calves should then transition more smoothly to exclusively solid feed when milk is fully
204 withdrawn at weaning. Although all treatment groups exhibited a growth check during weaning at
205 wk 7, this check was more pronounced in individually raised calves than in late and early paired
206 calves, indicating an advantage to being paired during the weaning phase. A reduced growth check at
207 weaning for group housed calves has also been reported in earlier studies (Chua et al., 2002; de Paula
208 Vieira et al., 2010). In addition to potential animal welfare benefits from the higher gains this early
209 advantage in BW is likely to benefit farm profitability; recent research has shown the advantages of
210 higher weight gains in calves on the onset of puberty and first lactation, as well as overall milk
211 production (Moallem et al., 2010; Soberon et al., 2012).

212 A recent paper found that social contact was associated with increased solid feed intake when
213 calves were fed a high intake of milk, but not when calves were fed low milk volumes (Jensen et al.,
214 2015). Feeding low volumes of milk increases calf hunger (de Paula Vieira et al., 2008), increasing
215 motivation to eat solid feed. Thus the effects of social housing on solid intakes are expected to be
216 greatest for calves with higher milk intakes, as in the current study.

217 In the current study TMR intake did not differ among treatments. This result contrasts with that
218 of Phillips (2004) in which calves reared in groups showed increased intakes of grass (but not starter)
219 relative to calves housed individually. The difference between these two studies may be due to
220 different types of solid feed intake motivation. In the current study, calves were fed 8 L/d and in the
221 study by Phillips (2004) calves received 4L/d. Increased milk allowance is thought to increase
222 motivation to consume forages (as reviewed by Khan et al., 2011), and all calves in this study
223 consumed high quantities of TMR. Intakes were more variable for calf starter, likely making it easier
224 to detect the beneficial effects of social rearing on calf starter intake. In contrast, Phillips (2004) fed
225 calves just 4 L of milk /d, likely leaving animals highly motivated to eat concentrate. In this context,
226 intakes of concentrates were likely consistently high, such that treatment differences were more
227 likely to be observed for forage intake.

228 The increased intake of solids may be due to social facilitation, social learning or some
229 combination. Social facilitation can be defined as "the initiation of a particular response while
230 observing others engaged in that behavior" (Galef, 1988); in this way the stimulus of an animal
231 eating or approaching the feed would increase the likelihood of the other calf in the same pen
232 performing the same behaviors. Social learning can be defined as learning that is influenced by
233 observation of, or interaction with, another individual (Keeling and Hurnik, 1996). In the previous
234 literature on the development of feeding behavior in farmed species some authors have implicated
235 social facilitation (e.g. Ralphs et al., 1994) and other social learning (e.g. Launchbaugh and Howery,
236 2005), but in our view distinguishing between these mechanisms is not possible based on the current
237 data and should be explored in future work. Also, if socially reared calves eat more solids simply
238 because their attention is drawn to the feed by their social partner, other methods that draw attention
239 to the feed may also be effective at increasing early intakes. For example, mechanically shaking or
240 changing the feed might also increase attention and ultimately increase intakes. In piglets, it has been
241 shown that a 'play feeder' (an open trough with 3 protrusions to stimulate exploration) can increase

242 creep feed intake (Kuller et al., 2010). To our knowledge this approach has never been applied to
243 dairy calves.

244 In conclusion, dairy calves benefit from early social housing in terms of increased solid intakes
245 and increased gains. To achieve these benefits calves should be grouped within 3 weeks of life.

246
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248
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261
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337 Figure legends

338 Figure 1. Least square mean (\pm SE) of weekly a), total mixed ration (TMR; kg of DM) b) calf starter
339 (kg of DM) and c) solid feed dry matter intake (DMI; kg of DM) for early-paired (paired at 6 ± 3 d
340 old; n=8 pairs), late-paired calves (paired at 43 ± 3 d old; n=8 pairs) and individually (n=8 calves)
341 from 3 to 10 wk old.

342 Figure 2. Least square mean (\pm SE) of average daily gain (ADG) (kg/d) for early-paired (paired at 6
343 ± 3 d old; n=8 pairs), late-paired calves (paired at 43 ± 3 d old; n=8 pairs) and individually (n=8
344 calves) during the a) whole experimental time (wk 3 to wk 10) b) pre-weaning (wk 3 to wk 6) and c)
345 weaning (wk 6 to wk 10) periods.

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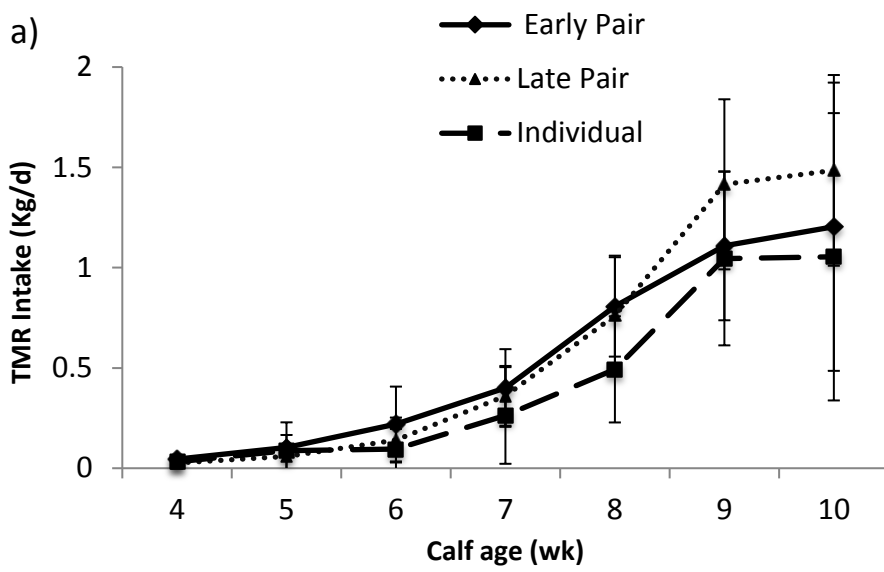
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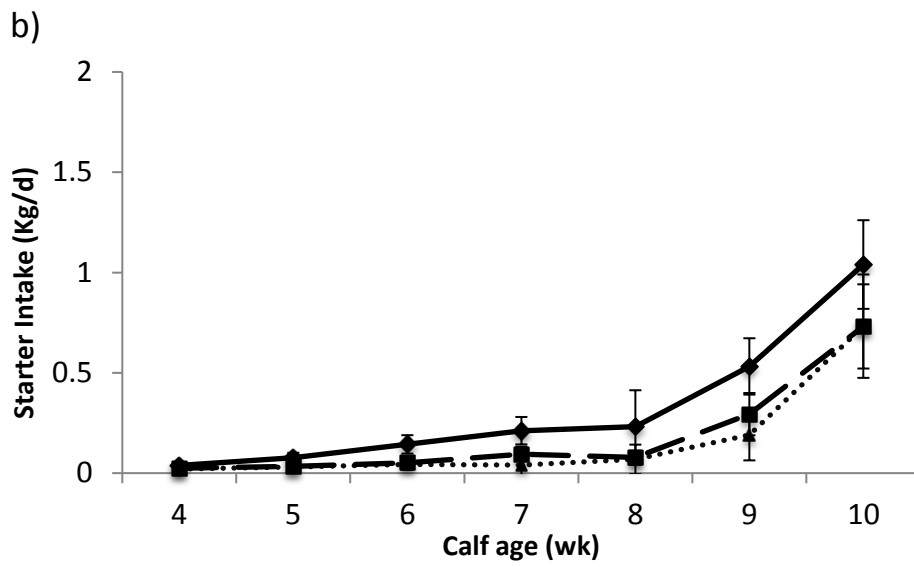
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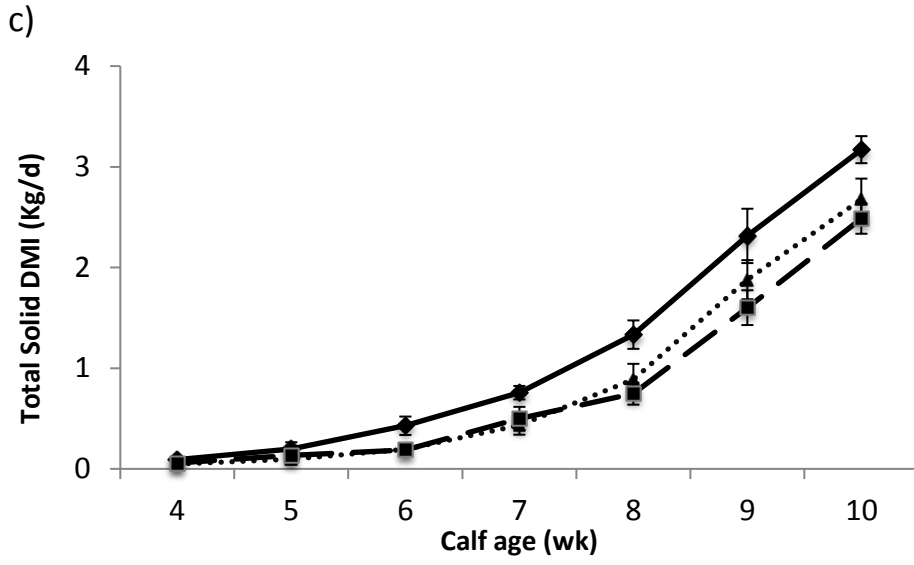
375 Figure 1.
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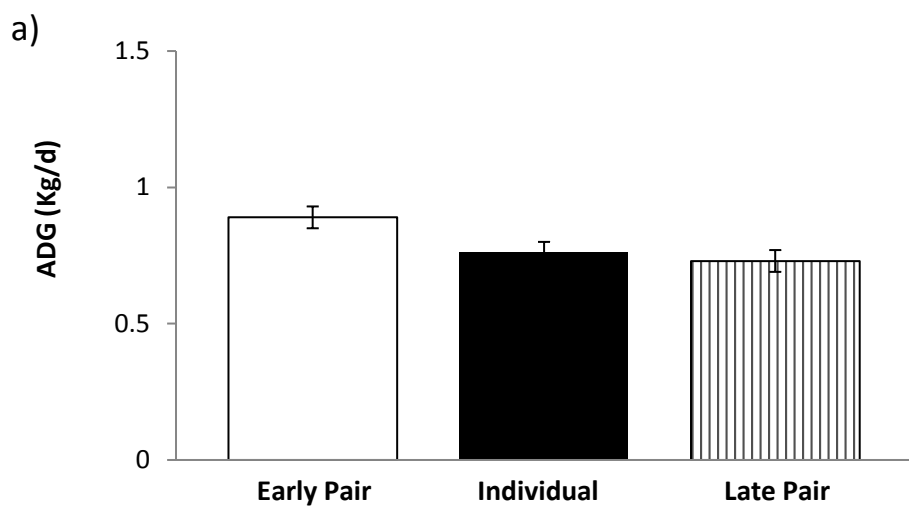


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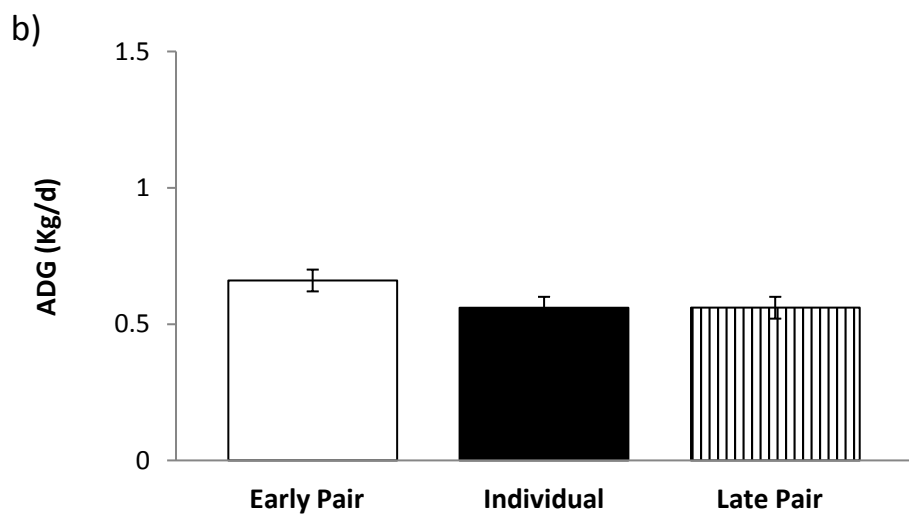
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399 Figure 2.



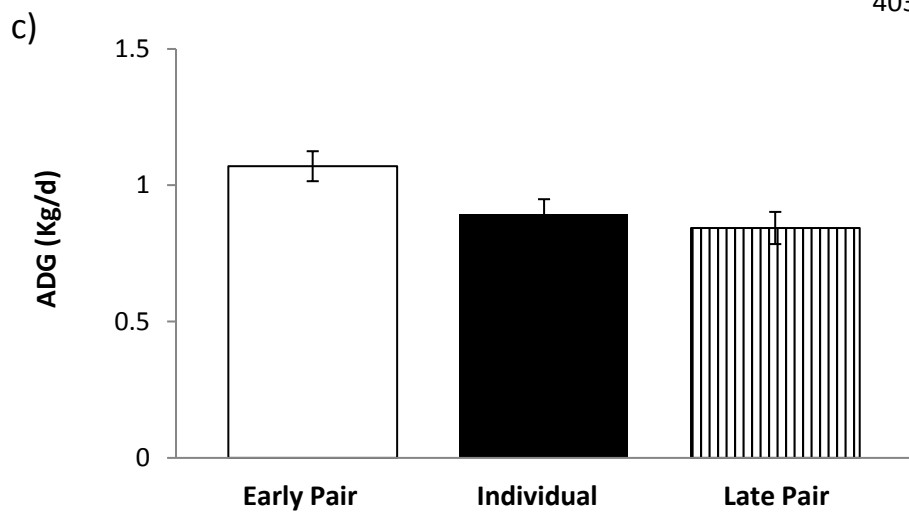
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