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1 **Economic values for lean meat- and fat efficiency in Norwegian Landrace**
2 **nucleus pig population**

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12

13 **Abstract**

14 A bio-economic model was developed to estimate economic values for new efficiency traits
15 for fattening pigs in Norwegian Landrace. These traits were lean meat - (**LME**) and fat
16 efficiency (**FE**). In addition, days from 40 to 100/120 kg live weight (**DAYS**), lean meat
17 percentage (**LMP**) and fat content on carcass (**FC**) were included in the model and referred to
18 as breeding goal A. To compare LME and FE with total feed intake (**FI**), a model including
19 FI, LMP and DAYS was developed and referred to as breeding goal B. The standardized
20 economic values for LME and FE were 8.9 and 2.9 EUR/ σ_a , respectively. There was a larger
21 variation in the index for breeding goal A than B. The results suggested that the two
22 efficiency traits had a high economic importance in pork production and that there was a big
23 potential for increased genetic gain in profit by using breeding goal A.

24

25 **Keywords:** animal breeding, economic model, feed efficiency, Norwegian Landrace,
26 standardized economic value

27

28 **Introduction**

29 The purpose of breeding programs is to improve the profitability of livestock production.
30 Profitability is approximated by the breeding goal for the population. A breeding goal states
31 which traits that are important to improve and could be of both economical and societal interest
32 (Olesen et al., 2000; Kanis et al., 2005). The purpose of pig breeding is to meet the demands
33 for high quality meat production in a sustainable way. The breeding goal should therefore
34 include traits that increase the commercial producer's income and reduce their costs in pork
35 production. This includes traits such as growth and feed efficiency, but also demands from the
36 society, with traits such as meat quality, animal welfare and health (Kanis et al., 2005; Flint
37 and Woolliams, 2008). The traits are often of different importance, and to weigh the traits in
38 the breeding goal, their economic value needs to be estimated (De Vries, 1989). The Norwegian
39 Landrace (**NL**) is a maternal breed and the breeding goal consists of seven trait groups with a
40 number of traits within each group. These groups are production, carcass quality, meat quality,
41 litter size, reproduction, maternal ability and robustness, and all have different weights in the
42 total merit index (Norsvin, 2016). The NL is a feed efficient and lean breed with a low amount
43 of back fat (Gjerlaug-Enger et al., 2012). This is due to extensive selection for reduced back
44 fat, increased lean growth and reduced feed intake per kg growth (**FCR**) over 50 years.
45 Martinsen et al. (2015) suggested that this selection was more related to resource allocation
46 rather than selection for efficiency to utilize nutrients. The same study therefore established
47 two new efficiency traits, indicating how well the animal utilizes the feed for lean meat and fat
48 production. The traits were named lean meat efficiency (**LME**) and fat efficiency (**FE**) and
49 describes how much feed needed for production of one extra kg lean meat and fat (as a
50 deviation from the mean). The aim of this paper was to assess the economic importance of the
51 new efficiency traits in pork production compared to a traditional feed consumption trait and
52 estimate the economic values for the two new efficiency traits, lean meat- and fat efficiency.

53 **Material and Methods**

54 *Model Description*

55

56 The breeding company Topigs Norsvin (TN; Vught, the Netherlands) provided data from
57 their boar test station in Norway, and this was used as input for the economic model. The
58 model describes the income and costs in the purebred NL fattening pigs, from they are
59 bought, as feeder pigs (40 kg) to they are slaughtered (100/120 kg).

60 *Traits Evaluated*

61

62 All traits were recorded on purebred NL boars from 40 nucleus herds in Norway at the boar
63 test station. The boars are housed in pens with a Feed Intake Recording Equipment (FIRE)
64 station (Osborne Industries Inc., Osborne, KS, USA), with 12 pigs in each pen. Here, individual
65 feed intake and weight are recorded. The boars weight ~40 kg live weight when they enter the
66 test, and about 100/120 kg when they end the test and their body composition is scanned by
67 computed tomography (CT). Boars finishing the test before March 1, 2012 were CT-scanned
68 at 100 kg live weight, while boars finishing after this date were scanned at 120 kg. Through
69 image analysis from the CT-scans, lean meat- and fat content are registered. In total, 8,161 NL
70 boars had information on the traits included in the bio-economic model. These traits were lean
71 meat efficiency (**LME**) and fat efficiency (**FE**) (described in Martinsen et al. (2015)), number
72 of days from 40 to 100/120 kg (**DAYS**), lean meat percentage (**LMP**) and fat content on the
73 carcass (**FC**). To compare the new efficiency traits with total feed intake in the test period (**FI**),
74 an economic model including FI, DAYS and LMP was developed. This was referred to as
75 breeding goal B. The economic model including LME, FE, DAYS, LMP and FC was referred
76 to as breeding goal A.

77

78 *Days from 40 to 100/120 kg live weight*

79 Days from 40 to 100/120 kg live weight is a measure for the individual growth. The trait is
80 number of days between the animal is bought as a feeder pig (40 kg) and slaughtered at 100/120
81 kg. A reduction in this trait is preferable, as a faster growing pig would use less days to reach
82 the end weight, and thus less feed. In addition, the farmer save costs in housing and labor per
83 unit produced when the animals are slaughtered earlier.

84 *Lean Meat Percentage*

85 Lean meat percentage is a measure for carcass quality in the pig, and influences the income of
86 the farmer. The price per kg for the carcass is influenced by LMP, as the market prefers a lean
87 carcass (high LMP). By improving this trait, the income of the farmer will thus increase.

88 *Fat Content on the Carcass*

89 Fat content on the carcass represents the amount of fat on the carcass, which represents a cost
90 for the farmer. By reducing FC on the fattening pigs, feed costs for fat deposition is reduced,
91 and the farmers total cost decreases. This trait is included in the calculation of feed intake costs
92 together with FE.

93 *Total Feed Intake in the Test Period*

94 Total feed intake in the test period is a measure of individual total feed intake during the test
95 period. A reduction in this trait is preferable, as animals with low feed intake saves feed costs
96 in the production.

97 *Estimation of Lean Meat and Fat Efficiency*

98 Both efficiency measurements were analyzed in an random regression animal model, and
99 prediction of breeding values was performed in a univariate analysis using DMU (Madsen and

100 Jensen, 2013). The fixed effects used in the model were determined based on an analysis of the
101 traits in SAS.

102 To estimate LME and FE, FI was analyzed as the trait with amount of lean meat and fat
103 included through random regressions in the model. For analyzing FI the following model was
104 used:

$$105 \mathbf{FI}_{ijknoqrst} = \mathbf{HY}_i + \mathbf{BM}_j + \mathbf{ST}_k + \mathbf{SEC}_n + \beta_{lm} \times \mathbf{LMEAT}_o + \beta_{fat} \times \mathbf{FAT}_q + \beta_{amw} \times \mathbf{AMW}_r + \mathbf{a}_s + \mathbf{pen}_t + \mathbf{a}_{ps} \times \mathbf{lmeat}_o + \mathbf{a}_{fs} \times \mathbf{fat}_q + \mathbf{e}_{ijknoqrst} \quad [1]$$

106 The fixed effects included in the model were herd-year (**HY**), birth month (**BM**), scanning time
107 (**ST**) and section (**SEC**). Number of levels in *i* were 207 and for *j* it were 12. For *k* number of
108 levels were two (finishing before or after March 1, 2012) and *n* had 132 levels. The boars'
109 amount of lean meat (**LMEAT**) and fat (**FAT**) on the carcass and accumulated metabolic body
110 weight (**AMW**) were included as fixed regression covariates. As a measure of the individual
111 genetic potential for LME and FE, amount of lean meat (**lmeat**) and fat (**fat**) were also included
112 as random regression covariates (\mathbf{a}_{ps} and \mathbf{a}_{fs} , in the model) (Martinsen et al., 2015). Lean meat
113 efficiency and FE represents the amount of feed needed to produce one extra kg of lean meat
114 or fat, respectively, and are regression coefficients. The animals' breeding value (\mathbf{a}_s) and pen
115 (**pen**) were included as random effects. In this model, \mathbf{a}_s represent the genetic effect of the
116 animal on FI that is not explained by the genetic effect of fat and lean meat efficiency and is
117 referred to as the residual feed intake of the animal (Martinsen et al., 2015).

118 Since LME and FE are derived from estimates of model [1], direct phenotypic recordings are
119 not available for these traits. The fixed regression coefficients estimated by model [1] were set
120 as the mean for LME and FE, and are used in the profit equation to estimate the economic value
121 of these traits. The prediction of breeding values for FI, FC, LMP and DAYS was performed

122 in univariate models using the DMU (Madsen and Jensen, 2013). The following model was
123 used:

$$124 \mathbf{Y}_{ijklmn} = \mathbf{HY}_i + \mathbf{BM}_j + \mathbf{ST}_k + \mathbf{SEC}_l + \mathbf{a}_m + \mathbf{pen}_n + \mathbf{e}_{ijklmn} \quad [2]$$

125 Model [2] was identical to model [1], but did not include the fixed and random effect of lean
126 meat and fat content nor the fixed effect of accumulated metabolic body weight.

127 *Profit Function*

128

129 The profit function is a function consisting of the input and output per unit, to describe the
130 profitability of the unit. In this study, the profit was calculated per fattening pig. The input data
131 and means are presented in Table 1.

132 *Income*

133 In fattening pig production in Norway, the revenue comes from the value of the fattening pig
134 and subsidies. The value of the fattening pig is dependent on the settling price, which is
135 associated with the SEUROP carcass grading system for pigs. The system organizes the
136 carcasses into categories (S to R), depending on their LMP (Norwegian Meat and Poultry
137 Research Center, 2012). During recent years, the average LMP has been above 60%, and in
138 category S. The farmer is paid a bonus if LMP in the carcass is above 60% or given a reduced
139 price if LMP is lower. This bonus was set to +/-0.03 EUR per LMP above/below 60% (Table
140 2). The settling price depends on the carcass weight. The settling price for the carcass weight
141 was collected from Norsvin SA's economic analysis of pork production in 2014 (M. Narum,
142 Topigs Norsvin, Hamar, Norway, personal communication). The subsidies for this given
143 situation were set to 1.8 EUR/fattening pig (Table 2) and treated as a fixed income. The income
144 (**I**) of a fattening pig (**fp**) was calculated with the following model:

$$145 \mathbf{I}_{fp} = \mathbf{CW} \times (\mathbf{Pr}_{kg} + (\mathbf{LMP}_{fp} - 60) \times \mathbf{AdPr}) + \mathbf{S}_{fp} \quad [3]$$

146 where CW represents the carcass weight, Pr_{kg} is the settling price per kg. AdPr is the additional
 147 bonus per LMP above or below 60 % and S_{fp} is the fixed subsidies.

148 *Costs*

149 The costs included in the fattening pig production were the costs for feed for production and
 150 maintenance, costs to labor, machines and housing and fixed non-feed costs. The following
 151 model was used to calculate the costs (C_{fp}) of a fattening pig:

$$152 \quad C_{fp} = P_{feed} \times (\beta_{lm} \times \mu_{lmc}) + P_{feed} \times (\beta_{fat} \times \mu_{fc}) + P_{feed} \times (MAIN_{day} \times DAYS_{fp}) \quad [4]$$

$$153 \quad + (LAB_{day} \times DAYS_{fp}) + (HOU_{day} \times DAYS_{fp}) + FNF_{fp}$$

153 The feed costs for maintenance per day (MAIN) were calculated based on the equation for
 154 standard maintenance requirement given in NRC (2012), and multiplied by the number of feed
 155 days (DAYS). To calculate feed used for production of lean meat and fat, the fixed regression
 156 coefficients derived from model [1] ($\beta_{lm} = LME$ and $\beta_{fat} = FE$) were used with the amount of
 157 lean meat (μ_{lmc}) and fat (μ_{fc}) (Table 1). All feed requirements were multiplied by the cost per
 158 kg feed (P_{feed}) (Table 2). In addition, a fixed non-feed cost (FNF_{fp}) per fattening pig was
 159 included. This cost includes piglet price, veterinary, insurance, mortality and interests per
 160 fattening pig for all traits (Table 3). Since machines/buildings (HOU) and labor (LAB) were
 161 dependent on DAYS, these costs are not included in FNF. The cost function described in model
 162 [4] was related to breeding goal A. The estimated cost for breeding goal B (FI is analyzed
 163 instead of LME and FE) is identical to model [4], but parameters associated with feed intake
 164 estimation ($\beta_{lm}, \beta_{fat}, \mu_{lmc}, \mu_{fc}$ and MAIN) were replaced by FI multiplied with the feed price
 165 (P_{feed}). The profit per fattening pig was the difference between total income per fattening pig
 166 (I_{fp}) and total costs per fattening pig (C_{fp}) in both breeding goal A and B.

167

168 *Economic Values*

169

170 Economic values for the traits were estimated by improving the mean of the trait by 1%, while
171 the other traits remained constant. The following formula was used to estimate the marginal
172 economic value of the traits.

173 **Marginal economic value_n(MEV) = $\frac{P(\mu_n + \Delta n) - P(\mu_n)}{\Delta n}$** [5]

174 The difference in profit (P) between the original (μ_n) and the improved ($\mu_n + \Delta n$) mean was
175 divided by the change in the trait (Δn) and represented the marginal economic value of the trait
176 per trait unit. The marginal economic value was standardized by multiplying with the additive
177 genetic standard deviation (σ_a) for each trait.

178 *Indexes and Profit*

179

180 To compare the two breeding goals for production an index was calculated for both breeding
181 goals described below:

182 **Index_i = $\sum \text{MEV}_i \times \text{EBV}_{ij}$** [6]

183 The index was calculated as the summation of the product of the marginal economic value for
184 each trait (*i*) (MEV_i) and the estimated breeding value for the trait (EBV_{ij}) for each animal (*j*).

185 An economically weighted phenotype including the traits in breeding goal B was estimated for
186 each animal as showed in model [7].

187 **PROFIT_j = $\sum \text{MEV}_i \times \text{phenotype}_{ij}$** [7]

188 Individual profit for animal (j) was calculated based on their phenotype for trait (i) included in
189 breeding goal B and the economic value of the trait (j). This trait was named PROFIT and
190 breeding values were calculated with model [2].

191 **Results**

192 *Economic Values*

193

194 Table 1 gives the production means for NL pigs on the test station. The average carcass weight
195 of a purebred NL boar was 79.1 kg and LMP of 67.9%. The average fat content on carcass was
196 16 kg, and the boars used on average 66 days from 40 to 100/120 kg live weight at the test.
197 The marginal economic values (EUR per trait unit) are presented in Table 3. The marginal
198 economic value of FI was estimated to 0.3 EUR/kg feed. A 1% improvement of LME increased
199 the profit by 0.005 EUR, and feed used for lean meat production was reduced by 0.0015 kg.
200 This gave LME the highest marginal economic value of 18.3 EUR/kg feed/kg lean meat
201 deposited (unit regression coefficient). For FE, the 1% improvement gave a reduced use of feed
202 for fat production of 0.3 kg, which increased the profit by 0.12 EUR. The marginal economic
203 value for FE was 5.6 EUR/kg feed/kg fat deposited. In terms of carcass payment, LMP was an
204 important trait (Table 2). By improving LMP by 1%, to 68.5%, the profit increased by 1.7
205 EUR. The marginal economic value for LMP was 2.5 EUR/percentage. Fat content on the
206 carcass affected feed intake in this economic analysis of breeding goal A. A 1% improvement
207 in the trait was assumed (from 15.99 kg to 15.83 kg), and resulted in increasing the profit by
208 0.12 EUR. The marginal economic value for FC was 0.8 EUR/kg fat. For growth in the
209 fattening period, DAYS was included in the analysis. By reducing DAYS by 1% (0.7 days),
210 profit increased by 0.6 EUR per fattening pig and the marginal economic value was 0.9
211 EUR/day.

212 Table 3 also include standardized economic values (SEV), which makes it possible to compare
213 the economic values on the same scale i.e. change in profit from one genetic standard deviation
214 increase in each included trait (EUR/σ_a). Among the traits, LME was the trait that had the
215 highest economic importance (8.9 EUR/σ_a), whereas FE (2.9 EUR/σ_a) was the third most
216 important trait after LMP (4.5 EUR/σ_a). For DAYS, the standardized economic value was 2.6
217 EUR/σ_a . The trait FC was least important (1.1 EUR/σ_a). The trait FI had the second lowest
218 economic importance out of all six trait in the analyses (1.6 EUR/σ_a).

219 *Breeding Goals*

220

221 Table 4 shows the descriptive statistics for the EBV's for PROFIT and the indexes for breeding
222 goal A and B. The standard deviation of the EBV's for PROFIT was 23.3, while for the index
223 for breeding goal B the standard deviation was 36.3. For the index for breeding goal A, the
224 standard deviation was estimated to 52.2. The standard deviation suggested that the index for
225 breeding goal A had two times as high variation as the index for breeding goal B. The high
226 variance indicates that there is a bigger variation in the genetic potential for profit using
227 breeding goal A. Breeding goal A included LME and FE as feed efficiency measures, while
228 breeding goal B included FI. The rank correlation between the two indexes was 0.77. There
229 was a complete re-ranking of the ten best sires when breeding goal B was used instead of
230 breeding goal A, with no overlap among the ten best boars for the two breeding goals. The best
231 animals in breeding goal A had overall lower phenotypic FI than the best animals for breeding
232 goal B. However, the animals had poorer growth (higher DAYS).

233 **Discussion**

234 The study found economic values for LME and FE, together with directly observed traits
235 DAYS, LMP, FC and FI. Higher variance was observed in the index containing LME and FE
236 as feed consumption traits (breeding goal A) compared to the index for breeding goal B,

237 containing FI as the feed consumption trait. The results suggested that both efficiency traits are
238 important for profit and an inclusion of the traits in the breeding goal improves genetic gain,
239 since the index of breeding goal A shows a substantially higher variance.

240 The model constructed for breeding goal A in this study was only dependent on five boar traits,
241 as the aim was to estimate the economic value of LME and FE and not to describe the overall
242 complexity of the pork production in Norway. Therefore, the model constructed was simple,
243 but included the traits that are important regarding feed consumption and growth in pork
244 production.

245 The quality of the input data used for the base situation are important when calculating
246 economic values for traits. This study used input data from the boar test station, on purebred
247 NL. These data are used for the genetic evaluation of the boars and are a part of the higher
248 genetic level of the NL population as they are selected for the test station. This may influence
249 the input data through high LMP and short growth period, but should not influence the
250 economic value of the traits. The feed price and carcass price were market averages from 2014.

251 *Economic Values*

252
253 The marginal economic values in this study were presented per trait unit per fattening pig.
254 Other studies have estimated economic values for production traits in different breeds,
255 countries and with a different definition of production efficiency in the economic model
256 (Hermesch et al. 2003; Houska et al. 2004; Serenius et al. 2007; Houska et al. 2010). Economic
257 values across countries, breeding companies and breeds are difficult to compare due to different
258 definitions of production efficiency, different market and management conditions across
259 countries and different economic models (Houska et al., 2004). The standardized economic
260 values estimated for DAYS and LMP in this study were higher than the economic values TN

261 use. For FI, the economic value was slightly lower than what TN use. Still, the trait definitions
262 are not exactly the same, and our economic model is not very complex.

263 Serenius et al., (2007) mentioned the importance of what a realistic change in the trait is, when
264 marginal economic values are investigated. This study found a marginal economic value for
265 LME of 18.3 EUR/kg feed/ kg lean meat, which is high. However, it may not be realistic to
266 reduce the amount of feed used for one kg lean meat deposition by one kg. In 2014, the feed
267 used for one kg growth in Norwegian commercial fattening pigs was 2.74 kg (Ingris, 2014).
268 Feed for growth includes feed for deposition of fat, lean meat and other tissues as well as feed
269 for maintenance (Schinckel and de Lange, 1996). To reduce the amount of feed for production
270 of a kg lean meat by one kg might be unlikely, as there obviously is a biological limit for how
271 efficient a pig could be.

272 The genetic standard deviation of LME was low (0.5), and the standardized economic value of
273 the trait was 8.9 EUR/ σ_a . Lean meat efficiency is not a phenotype that is observed, but a
274 regression coefficient estimating the estimated cost for production of one additional kg lean
275 meat (as a deviation from the mean). Lean meat efficient animals use less feed per kg lean meat
276 deposited, i.e., the breeding value is negative and low. Even though the marginal economic
277 value of LME was high per kg feed/kg lean meat, a small change in the trait was observed
278 when improved by 1%. This small change reduced the feed cost and made a change in profit.
279 This change in profit was big compared to the change in the trait and thus a high economic
280 value per trait was calculated. The high economic value for LME is also dependent on the
281 amount of lean meat on the fattening pig. As the trait is a result of FI as a function of amount
282 of lean meat on the fattening pig, the trait is expressed as kg feed/kg lean meat. The same
283 situation occurs for FE. The lower economic value is related to the lower amount FC on the
284 carcass compared to lean meat. For both FE and LME, the economic value is dependent on the

285 production level (amount of lean meat and fat), which makes it even more difficult to compare
286 to other studies (Hermesch et al. 2003).

287 All feed related traits had high economic values, and a significant influence on the pork
288 production profit. These economic values are highly dependent on the feed price, and a market
289 change in the feed price would influence the economic importance of feed consumption traits
290 in the breeding goal. The current situation in Norway is low feed prices and the importance of
291 feed efficiency traits is expected to increase as feed prices rise.

292 *Breeding Goals*

293
294 The two breeding goals defined in this study contained few, but important, production traits in
295 pig breeding. Breeding goal A represented the new traits LME and FE, established in Martinsen
296 et al. (2015), while breeding goal B represented a more traditional breeding goal with FI, DAYS
297 and LMP included. Profit as a trait (PROFIT) was the summation of the phenotypes of the traits
298 included in breeding goal B multiplied with the economic value of each trait. This was a simple
299 way of modelling profit (by phenotypes), but Meuwissen and Goddard (1997) concluded that
300 profit was a quite robust trait for selection and Pérez-Cabal and Alenda (2003) suggested that
301 profit as a trait should be implemented in the genetic evaluation of Spanish Holstein. As the
302 standard deviation of the EBVs for PROFIT was lower than the standard deviation for the
303 indexes for both breeding goal A and B, it seemed like more complex modelling of feed
304 consumption increased the standard deviation. The index resulting from breeding goal A had
305 the highest variance, which suggested that inclusion of LME and FE in the breeding goal would
306 result in bigger genetic gain for profit. Still, it is important to take into consideration the use of
307 univariate analyses of the traits. No genetic correlations among the traits are accounted for in
308 the prediction of breeding values, and hence some breeding values might be over- or
309 underestimated which might affect the index (Smith, 1983). The reason for not performing
310 multitrait analyses was problems with convergence. Breeding goal A also included more traits

311 in the index, which might influence the variation in the index. In addition, the traits included
312 in breeding goal A have a considerably higher economic value than FI in breeding goal B.

313 The rank correlation between the indexes for the breeding goal was low (0.77), and suggested
314 that the two breeding goals are not the same. The re-ranking of the sires suggested that the new
315 efficiency traits contribute new information, not described in breeding goal B with FI as feed
316 consumption trait. No sires were selected in common for the two breeding goals. The efficiency
317 traits does not necessarily say which animals that have lowest feed intake or highest growth,
318 but who deposit lean meat and fat most efficient. The animals with highest feed intake does not
319 necessarily have to be less efficient. However, when comparing the best boars for the two
320 breeding goals, the boar selected with breeding goal A had lower FI and poorer growth than
321 the animals selected with breeding goal B. This highlights the importance of including genetic
322 relationships between the traits in the breeding value estimation.

323 **Conclusions**

324 Both of the new efficiency measures had an economic importance in pork production. Lean
325 meat efficiency had a high economic value compared to other production traits in NL. When
326 comparing the breeding goals, including LME and FE in the breeding goal could potentially
327 give a bigger genetic gain for profit than the breeding goal including FI. The rank correlation
328 between the breeding goals proved that the new efficiency traits does not describe the same as
329 FI, and includes additional information to improve the genetic evaluation of boars.

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332

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374 selection. *J. Anim. Sci.* 56, 1057-1064.

375

376 Table 1. Input data, mean performance from purebred Norwegian Landrace boars at test station.

Variable	Performance mean
Carcass weight (kg)	79.1
Days in test (days)	66.3
Total feed intake in the test period (kg)	152.1
Maintenance requirement/day (kg)	1.2
Lean meat percentage (%)	67.9
Average fat percentage (%)	20.4
Lean meat content (kg)	52.3
Fat content on the carcass (kg)	15.9
Average lean meat efficiency (kg feed/kg lean meat)	-0.03
Average fat efficiency (kg feed/kg fat)	2.24

377

378 Table 2. Market prices related to costs and income in fattening pig production (M. Narum,

379 Topigs Norsvin, Hamar, Norway, personal communication). The currency was set at April 13,

380 where 1 EUR = NOK 9.3.

Variable	EUR(€)
Price/kg carcass weight	2.75
Additional price per kg if lean meat percentage above or below 60 %	0.03
Subsidies per fattening pig	1.83
Cost /kg feed	0.34

381

382

383 Table 3. Marginal economic values (MEV) expressed in EUR (€), genetic standard deviation
 384 (σ_a) and standardized economic values (SEV) for the five traits; Total feed intake in the test
 385 period (FI) Lean meat efficiency (LME), fat efficiency (FE), days from 40 to 100/120 kg live
 386 weight (DAYS), lean meat percentage (LMP) and fat content on the carcass (FC). All traits are
 387 expressed on a fattening pig-basis. The currency was set at April 13, where 1 NOK = 9.3 EUR

Trait	MEV (€)	σ_a	SEV (€/ σ_a)
FI (kg)	0.3	4.7	1.6
LME (kg feed)	18.3	0.5	8.9
FE (kg feed)	5.6	0.5	2.9
DAYS (days)	0.9	2.8	2.6
LMP (%)	2.5	1.8	4.5
FC (kg)	0.8	1.4	1.1

388

389

390 Table 4. Number of observations (n), standard deviation (SD), minimum value (Min) and
 391 maximum value (Max) for index calculated for breeding goal A, breeding goal B and breeding
 392 values for profit as a trait (EBVprofit). Breeding goal A contain lean meat efficiency (LME),
 393 fat efficiency (FE), fat content on the carcass (FC), lean meat percentage (LMP) and days
 394 between 40 to 100/120 kg live weight (DAYS). Breeding goal B contains total feed
 395 consumption in the test period (FI), lean meat percentage (LMP) and days from 40 to 100/120
 396 kg live weight (DAYS). Profit as a trait was the summation of the product of the phenotypes
 397 for the traits included in breeding goal B and the economic value of each trait.

	Breeding goal A	Breeding goal B	EBVprofit
n	8161	8161	8161
Mean	41.9	21.1	9.6
SD	52.2	36.3	23.2
Min	-137.9	-135.8	-89.7
Max	311.3	160.4	135

398