Response, Effectiveness and Accuracy of Different Selection Methods and Intensities In Dairy Cattle

(Respon, Efektivitas, dan Kecermatan Seleksi Individu Sapi Perah pada Berbagai Metode dan Intensitas Seleksi)

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Abstract. A data set of dairy cattle production and reproduction taken from Baturraden Dairy Cattle Breeding Centre (*Balai Besar Pembibitan Ternak Unggul; BBPTU*) was used in the study. The data included were 180 records of milk production collected from first, second and third lactation. The objectives of the study were : (1) to estimate heritability and repeatability of the milk production, (2) to compute accuracy, response and effectiveness of individual selection on different selection methods and intensities, (3) to study the best lactation period for selection in dairy cattle. Some conclusion can be drawn: (1) the estimated repeatability of milk production was considered low, the opposite was true for heritability estimate, (2) the selection response and its effectiveness increased when the number of animals maintained in the population decreased, (3) the selection accuracy increased along with the increased of number of record included, (4) the highest selection accuracy was obtained from individual selection with three records whilst the family selection resulted in the lowest selection accuracy. It was also concluded that selection in dairy cattle can be done as early as the first lactation and the accuracy will be increased if combined with the information from relatives.

Key Words: dairy cattle, effectiveness selection method

Introduction

Milk production can be improved by selection (Powell *et al.,* 2003). Minkema (1993) described selection in animal breeding as choosing animals in the population for future breeding. The ultimate objective of selection is to change the alleles frequency (Warwick *et al.,* 1995). It takes time for selection to see its impact on the population (Bakker and Pomiankowski, 1995; Gray and Cade, 1999; Heringstad et al, 2000). Warwick *et al.* (1995) further described selection as an activity to select animals that have better genetics makeup for breeding and cull the rest of the population. The genetics of animal is visible and only its performance or production that is measurable (Wilcox *et al.*, 2003; Georges et al, 2005). The genetic ability of dairy cattle can be predicted by giving them an uniform environment so that the difference of milk production they have is due to the genes combination controlling its phenotype (Wiggans, 1991).

There are many different methods of selection namely individual, family, combination between individual and family, pedigree, collateral relative and progeny-test based selection (Minkema, 1993; Hardjosubroto, 1994; Warwick *et al.*, 1995). Performing selection in animal breeding includes these steps: data correction, estimating heritability, estimating breeding value, ranking the candidates based on the estimated breeding value (EBV) and compute the selection response (Adjisoedarmo, 2004; Spellman and Garrick, 1998). Selection response is defined as the increase of phenotypic mean compared with the previous generation after the population undergoes selection. It is common to measure the predicted selection response even though the realized selection response can be obtained after selection. The purpose of predicting selection response is to know how much phenotypic gain will be obtained from selection before phenotypic data of the selected progenies becomes available.

Selection method can also be evaluated by its effectiveness and accuracy. Effectiveness of selection is a measure of how many percent increase of the phenotype from the population mean. Selection accuracy associates with the selection criterion (criteria) and breeding value of the animal.

The objectives of the study were to (1) estimate heritability and repeatability of milk production of dairy cattle, (2) to compute accuracy, response and effectiveness of individual selection on different selection methods and intensities, (3) to study the best lactation period for selection in dairy cattle.

Research Methods

The study was conducted in Dairy Cattle Breeding Centre of Baturraden (*Balai Besar Pembibitan Ternak Unggul; BBPTU*). The data was analyzed in applied animal breeding laboratory of Animal Science Department, Jenderal Soedirman University, Purwokerto. The data include 180 records of milk production, consisting of 60 data of first lactation, 60 data of second lactation and 60 data of third lactation. The data was obtained from production and reproduction records of dairy cattle available in the Dairy Cattle Breeding Centre of Baturraden (*Balai Besar Pembibitan Ternak Unggul; BBPTU*). The data were then tabulated according to the individual and its parents. Information regarding date of birth, date of parturition, age of parturition, lactation period, days of milking and milk production were also tabulated. A record is discarded and excluded in the analyses if the number of days of lactation is less then 120 days as well as record that has incomplete information (Marti and Funk, 1994).

In this study, milk production is defined as total production of a cow on a lactation period. Lactation period is defined starting from a cow produces milk until the dry period (a cow is not milked anymore). The days of lactation include total number of days when cows are milked on a lactation period. The age of parturition of a cow is the age (month) when a cow gives birth. Selection means to choose animals as parents for later generation and cull the rest of the population; selection is only for females (sex-limited selection). Selection methods applied in the study were: (1) individual selection, family selection and combination selection combining individual and family information. Selection intensity is the differential selection expressed in the standard deviation, which is the proportion of the maintained animals in the population. Different selection intensities of 0,30, 0,40, 0,50, 0,60 and 0,70 were applied in the study.

All data that meet the requirements were corrected to days of milking and equally-matured age according to Santosa (2006). The heritability of milk production was then estimated with the paternal half-sibs correlation and the repeatability was estimated through inter-class correlation. Individual, family and combination between individual and family selection methods were used to estimate the animals breeding value. The estimated breeding value (EBV) of animals obtained were ranked then selection response and effectiveness of the different selection methods were computed. The selection accuracy of the three selection methods was finally calculated.

Results and Discussions

One hundred and eighty records of milk production coming from the first three lactation were analyzed. The average of milk production along with its standard deviation as well as its coefficient of variation are presented in Table 1. The average of milk production in Dairy Cattle Breeding Centre of Baturraden (*BBPTU*) is 3141,13 ± 482,48 l or 9,39 *l* per day. The means of milk production for first, second and third lactation are 3031,61 ± 582,42 *l,* 3112,32 ± 651,74 *l* and 3279,45 ± 791,50 *l,* respectively. The milk production in Dairy Cattle Breeding Centre of Baturraden (Balai Besar Pembibitan Ternak Unggul; BBPTU) is higher than those in Yogyakarta 2651,46 l (Siswadi, 1987), in East Java: Malang 3090,75 *l* (Ekokapti, 1989), West Java: Cianjur 7,26 *kg*; Sukabumi 7,96 *kg;* Bogor 6,09 *kg* (Sitorus *et al.,* 1980).

However, the report from this study is much lower than those in Garut 13,32 *kg* (Sopiyana, 2005), Bandung 12,11 kg (Suamba, 1994), Central Java : Banyumas 3841 *kg* (Herijanto, 2000), Puerto Rico (5138 ± 1196 *kg)*, Columbia (5452 ± 1473 *kg*) and the USA (8672 ± 1756 *kg*) (Stanton *et al*., 1990).

Table 1. Description of the milk production data

Milk production	Lactation 1 (*l*)	Lactation 2 (*l*)	Lactation 3 (*l*)	Lactation 1, 2, 3 (*l*)
Means	3031,61	3112,32	3279,45	3141,13
Standard deviation	582,42	651,74	791,50	482,48
Coefficient of variation	19,21	20,94	24,14	15,36
Minimum	1753,59	1374,88	1187,00	1964,24
Maximum	4252,95	4694,94	5120,97	4544,97

Hardjosubroto (1994) reported that the milk production of Indonesian Holstein Frisian is about 2500 – 3500 *l* per lactation.

Milk production generally increases from the first to the third lactation. This is understood because during which the cow is on its productive period. According to Schmidt and Van Vleck (1974) milk production will reach its maximum when the cow reaches 6 to 8 years of age. On that period, the cow is biologically mature then its production will gradually decrease thereafter. Herijanto (1996) citing from Johansen and Rendel (1972) explained that the milk production will keep increasing along with the increase of cow age and this associates with the increase in body weight which is correlated with the size of the digestion and mammary systems. The capacity of milk production will keep increasing up to the age of 6 – 8 years and then it will decrease gradually until the cow is unproductive. Up to the age of 4 – 5 years, the milk production reaches about 95 – 98 percent of the peak production. Warwick and Legates (1979) reported that milk production of dairy cattle will keep increasing since the first lactation (24 months of age) until the age of 6 – 8 years.

Heritability is estimated by paternal half-sibs correlation involving sires where progenies are nested within sires (Warwick *et al*., 1995). The estimated heritability for milk production trait obtained from this study is 0,38 □ 0,45, which is still in the range on the estimates reported in the literatures. Purnomo (1986), Supiyono (1986) and Maylinda (1986) reported heritability for milk production of 0,32 □ 0.47, 0,24 □ 0,33 and 0,43 □ 0,74, respectively. Summarizing from different studies, Warwick *et al*. (1995) reported the heritability for milk production of dairy cattle of 0,20 – 0,30.

The relatively high heritability estimate on this study could be caused by the size of the data used in the analysis, which is relatively small. In addition, the analysis only considered the effect of the variability of the milk production from cows between sires through the paternal half-sibs correlation and excluded other effects such as mates. Warwick *et al*. (1995) highlighted that the estimates of heritability may vary between breeds within the different environments, or between races selected differently. In order to get the heritability estimate with small standard error, the number of data is suggested to be numerous for instance by increasing the number of sires and progenies per sire. The estimated repeatability obtained from this study is 0,26 which is categorized low according to Hardjosubroto (1994).

The difference between the phenotypic mean of the progenies of the selected parents and the phenotypic mean of the selected parents is known as selection response. This is also called the realized selection response because it really measures the phenotypic gain after selection is applied. In addition to the realized selection response it is also common to calculate the predicted selection response. The purpose of calculating the predicted selection response is to know how much the phenotypic mean will increase after the selection. This calculation is usually done before the phenotypic data from the progenies of the selected parents is available.

Table 2 shows that the selection response and its effectiveness increase if the percentage of the animals maintained in the population decreases.

Table 2. Response, effectiveness and accuracy of selection

Selection methods	Maintained (%)	Response	Effectiveness	Accuracy
Individual selection with 1 record	30	138,50	4,57	0,64
	40	115,81	3,82	
	50	95,52	3,15	
	60	76,41	2,52	
	70	59,70	1,97	
Individual selection with 2 records	30	187,34	6,10	0,81
	40	156,65	5,10	
	50	129,20	4,21	
	60	103,36	3,36	
	70	80,75	2,63	
Individual selection with 3 records	30	226,45	7,21	0,90
	40	189,36	6,03	
	50	156,17	4,97	
	60	124,94	3,98	
	70	97,61	3,11	
Family selection	30	123,54	4,08	0,51
	40	103,30	3,41	
	50	85,20	2,81	
	60	68,16	2,25	
	70	53,25	1,76	
Combination selection (individual and family selection)	30	141,26	4,66	0,65
	40	118,12	3,90	
	50	97,42	3,21	
	60	77,94	2,57	
	70	60,89	2,01	

This increase occurs in all of the selection methods. The highest selection response and its effectiveness are obtained from individual selection with three records, followed by individual selection with two records, combination between individual and family selection, individual selection with one record and family selection, subsequently. Warwick *et al.* (1995) explained that the magnitude of selection response is determined by many factors, among others heritability, selection intensity, variability of population and the selection method. The effectiveness of selection depends on three main factors, i.e. the accuracy of selection, selection intensity and the genetic variability. The big genetic variation opens the more opportunity for selection.

Conclusions

The estimated repeatability obtained is considered low, whereas the opposite ia true for the heritability estimate. Selection response and effectiveness of selection increase if the number of animals maintained in the population decreases. The accuracy of individual selection increases if the number of records per individual increases. The highest selection accuracy is achieved by individual selection with three records while family selection results in the lowest selection accuracy. Selection in dairy cattle can be done since the first lactation and its accuracy is increased if records from the family are included.

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