Effect of "owners" selection strategies on autumn weight in reindeer (*Rangifer t. tarandus*) calves

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Abstract: Many northern indigenous peoples, including the Sami are dependent on reindeer herding for their livelihood. In view of the socio-cultural and economical importance of reindeer herding, emphasis should be put on appropriate herd structure and selection strategies that maximise marketable products, such as meat (the primary marketable product nowadays). Empirical observations reveal that within a herd, some owners seem to have better productivity in term of carcass autumn weight of calves, than others. We hypothesized that there may be an "owner" effect in reindeer herding, i.e. some owners may be applying particular selection strategies that might be beneficial. We investigated this in three reindeer grazing districts in South Norway, using mixed linear models. We found that autumn carcass weight of calves varied significantly with year and "owner" within herd in all three districts. Consistently some particular owners within a herd had higher average autumn carcass weight of their calves than others. We attributed this difference to "individual selection strategies", meaning that some owners may follow more accurately the sex, age and weight-based recommended strategy and in addition, they may make superior choices when selecting animals for slaughtering. We conclude that individual owners have the capability, through appropriate selection decisions to improve the average annual autumn weight of their reindeer calves. This might be an important aspect of "Traditional Ecological Knowledge", in addition to the recommended modern sex, age and weight-based selection criteria.

Key words: body weight, owner effect, reindeer herding industry, selection strategy, traditional ecological knowledge (TEK).

Rangifer, 22 (2): 107-113

Introduction

Many northern indigenous peoples, including the Sami of Fennoscandia, the Sami, Komi and Nenets of western Russia, and numerous other peoples of Siberia and the Russian Far East are dependent on reindeer *(Rangifer tarandus)* herding for their livelihood and prevalence of their traditional culture (see Staaland & Nieminen, 1993; Gunn & Skogland, 1997).

In Norway, the Sami carry out reindeer herding over an area of approximately 140 000 km^2, *i.e.* 40% of the mainland of the country. In year 2000 about 2800 persons, with flocks constituting approximately 180 000 reindeer, owned reindeer in Norway (Reindriftsforvaltningen, 2001). In view of the numbers of owners and their socio-cultural and economical importance, emphasis should focus on appropriate herd structures that maximise mar-

ketable products, mainly meat (the primary marketable product nowadays). Autumn carcass weight is therefore an important factor in assessing the productivity of the herd. Variation in body weight in reindeer depends on their stocking density (see *e.g.* Kumpula, 2001), but also the summer range conditions (Klein, 1965; Reimers, 1983) that may be associated with climatic variability (see review by Weladji *et al.*, 2002).

Empirical observations reveal that some flocks (i.e. animals owned by one person), within a district, have a better average performance (measured for example as calf carcass weight) than others. We hypothesized that if this is true, there may be some kind of "owner effect" in reindeer herding, i.e. that some owners may be applying some particular selection strategies that might be profitable. To investigate these empirical observations, we tested the hypothesis in Sør-Trøndelag and Hedmark grazing area. This is where a strategy, that combines a new herd structure and a new slaughtering scheme based on traditional knowledge and modern production theory, evolved in the early eighties (Lenvik, 1988), hereafter refer to as the "recommended strategy". The new herd structure is based on sex (the sex ratio of the breeding stock is skewed, with about 80% reproductive females), weight (retain heavy individuals), and age (slaughter old individuals for example, usually of age 10 years and above) selections, but also on the use of 1½-year-old bucks for breeding (Lenvik, 1988). The new slaughtering scheme promotes intensive calf slaughtering each year, basically 80% of the calves. This paper is concerned with two general questions. (i) Is there any "owner" effect within reindeer herding districts in southern Norway? (ii) If yes, what could be the possible explanations for such an effect?

Material and methods

Reindeer data

We used data from three reindeer grazing districts in Sør-Trøndelag and Hedmark Counties, South Norway (Fig. 1). In autumn when the semi-domestic reindeer are gathered for slaughtering, carcass weight, sex and weighing date, specified according to year, corresponding herd and identity of the owner - are recorded by the Reindeer Husbandry Office in Sør-Trøndelag. Carcass weight is equivalent to live mass minus head, skin, viscera, blood and hoofs from the wrist and down. From 1992 to 2000, carcass weight and sex of 7906, 9917 and 4595 calves were recorded in autumn (mid-October to mid-December) in Essand, Riast/Hylling and Elgå respectively. Carcass weight data for the year 1999 for the Elgå population (916 observations) are not included in the analysis because they were not slaughtered until late in January and in February.

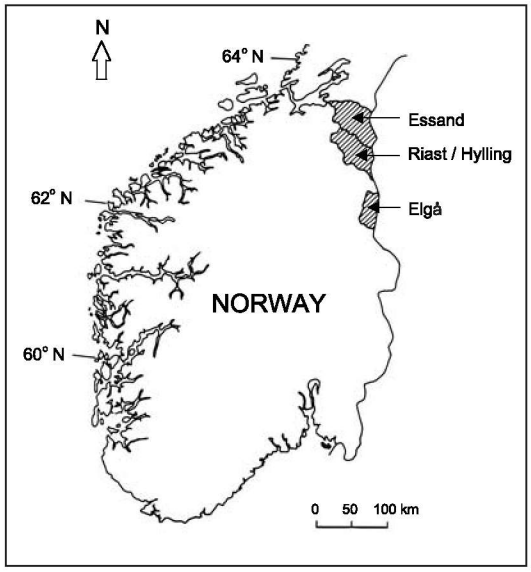

Fig. 1. Geographical location of the three studied populations within Sør-Trøndelag and Hedmark Counties, Norway.

Within Essand, Riast/Hylling and Elgå grazing districts, which consist of one co-operative working unit called "sida", there were 10, 10 and 6 business units called "driftenheter" respectively. "Owner" is defined in this paper as one of these units within the "sida" as identified by "code numbers", and therefore constitutes a "driftsenhet". However, only data from owners that have not been changed during 1992 to 2000 were included in the analyses for consistency. Individuals from a single "sida" are thus subjected to similar stochastic effects during the same period, as they move and graze together throughout the year. To protect anonymity, we used different alphabetical letters for each "owner". The records are available at the Sør-Trøndelag/Hedmark Reindeer Husbandry Office in Røros. See table 1 for sample size and least square means of autumn carcass weight per "owner" for each district.

Data analyses

The effect of "individual owner" on the variation in autumn carcass weight of calves was tested by the mixed linear models with both fixed and random effects (Littell *et al.*, 1996), using the Mixed procedure in SAS, version 8 (1999), with a 95% level of

Table 1. Overall mean (adjusted) autumn carcass weight (kg) ± standard error, and sample size (in bracket) for each owner in Essand (a), Riast/Hylling (b) and Elgå (c) between 1992 and 2000. The significances of the multiple comparisons testing for the difference (significance level is 5%) between owners within each district using Tukey-Kramer adjustment are also shown; only significant differences are reported. Owners are identified by capital letters within each district.

		B	C	D	E	F	G	H	I
(a) Essand									
A	19.180 ± 0.205 (1073)								***
B	19.122 ± 0.218 (0547)								***
C	19.041 ± 0.212 (0768)								**
D	19.333 ± 0.210 (0773)					*			***
E	19.168 ± 0.207 (0957)								***
F	18.965 ± 0.208 (0862)								**
G	19.030 ± 0.205 (1027)								***
H	19.242 ± 0.206 (1052)								***
I	18.551 ± 0.208 (0847)								
(b) Riast/Hylling									
A	21.955 ± 0.444 (1260)		**		***		***		
B	21.828 ± 0.444 (1108)				***	*	***		
C	21.555 ± 0.445 (0978)			**	***	***	**	***	
D	21.945 ± 0.444 (1210)				***		***		
E	22.388 ± 0.442 (1584)						***	*	
F	22.156 ± 0.443 (1324)						***		
G	21.154 ± 0.445 (1032)							***	
H	22.106 ± 0.443 (1421)								
(c) Elgå									
A	20.252 ± 0.557 (0798)		***						
B	20.283 ± 0.558 (0749)		***						
C	20.745 ± 0.554 (1370)								
D	20.303 ± 0.555 (1037)		***						
E	20.102 ± 0.559 (0641)		***						

* Adjusted P value < 0.05
** Adjusted P value < 0.01
*** Adjusted P value < 0.001

significance. "Year" was fitted as a random effect in the models because of repeated sampling within a year (see Kruuk *et al.*, 1999; Milner *et al.*, 1999). This allowed accounting for the dependency between calf weights within year. The following fixed independent variables were included in the models: sex of calves, weighing dates to account for temporal changes in calf mass (termed "age"), and individual owner. The interaction between sex and owner was also considered to assess whether the owner effect was more pronounced in one particular sex. Weighing date was the only continuous variable. Separate analyses were performed in each of the three populations. Least square means for individual "owners" were generated from the models and multiple comparisons were performed to test for the difference between "owners", using the Tukey-Kramer adjustment (*i.e.* a family wise comparison; SAS, 1999) that is suitable for unbalanced data (Sokal & Rolf, 1995; SAS, 1999), as in this study (see Table 1).

Calf carcass weight =
calf sex + calf "age" + individual owner + sex x owner + year + error

For illustration purposes (*i.e.* Fig. 2), we also estimated least square means by year for each owner in a separate set of analyses. Because least square means are generated only for fixed effects, we used

a general linear model of calf carcass weight on calf "age", calf sex, year, individual owner, year x owner and sex x year for each district:

Calf carcass weight =
calf sex + calf "age" + year + individual owner + sex x year + year x owner + error

Finally, to compare the average calf autumn weight between the three districts, we ran a single mixed linear model with calf carcass weight as response and weighing date, calf sex within district, owner within district, and district as fixed predictor variables. Year was fitted as random variable and differences between the generated least square means for the three districts were assessed by multiple comparisons using Tukey-Kramer adjustment procedure (Sokal & Rolf, 1995; SAS, 1999). We did not include density (population size per area) in this model for two reasons: first, the available data show little (sensu Gaillard *et al.*, 2000) year-to-year variation in crude density within each district (Coefficient of variation, CV = 7.57% in Essand, CV = 9.09% in Riast/Hylling, CV = 2.87% in Elgå) and, second, it appears that reindeer numbers were actually more stable during the study period than shown by the records (Helge Hansen, pers. obs., Senior reindeer officer, Sør-Trøndelag/Hedmark reindeer grazing area, 2001). Such doubt about the validity on the density data may lead to erroneous interpretation of the density effect.

Results

Autumn carcass weight of calves varied significantly with "owner" in all three districts (Table 2). There was also an effect of calf sex (Table 2), male calves being on average heavier (Essand: 1.61 kg ± SE 0.16; Riast/Hylling: 1.78 kg ± SE 0.13; Elgå: 1.40 kg ± SE 0.20) than females. The interaction between calf sex and "owner" was significant in Essand but not in Riast/Hylling and Elgå (Table 2), suggesting that the observed "owner" effect may be sex specific, at least in Essand, but also that herders in Riast/Hylling and/or Elgå may be consistent with their management practice regarding sex structure in their population. The estimated variance components for year effect were significant in all three districts (Essand: 0.332 ± SE 0.170, P = 0.026; Riast/Hylling: 1.726 ± SE 0.866, P = 0.023; Elgå: 2.417 ± SE 1.298, P = 0.031).

Results of the multiple comparisons of least square means between different "owners" revealed significant differences between several owners in all districts (Table 1), consistent with the reported empirical observations. In Essand, "Owner" coded I had lower (adjusted $P < 0.001$) average autumn carcass weight than all other owners, and "owner" F had lower average autumn carcass weight (adjusted P = 0.04) than "owner" D (Table 1a). In Riast/Hylling, "Owner" G had lower (adjusted $P <$ 0.001) average autumn carcass weight than all other owners, and "owner" E had higher average autumn carcass weight (adjusted $P < 0.04$) than all other owners but "owner" F (adjusted P = 0.18) (Table 1b). In Elgå, "Owner" C had higher (adjusted $P < 0.001$) average autumn carcass weight than all other owners (Table 1c). This was further illustrated when we plotted the yearly least square mean carcass weight of reindeer calves from 1992

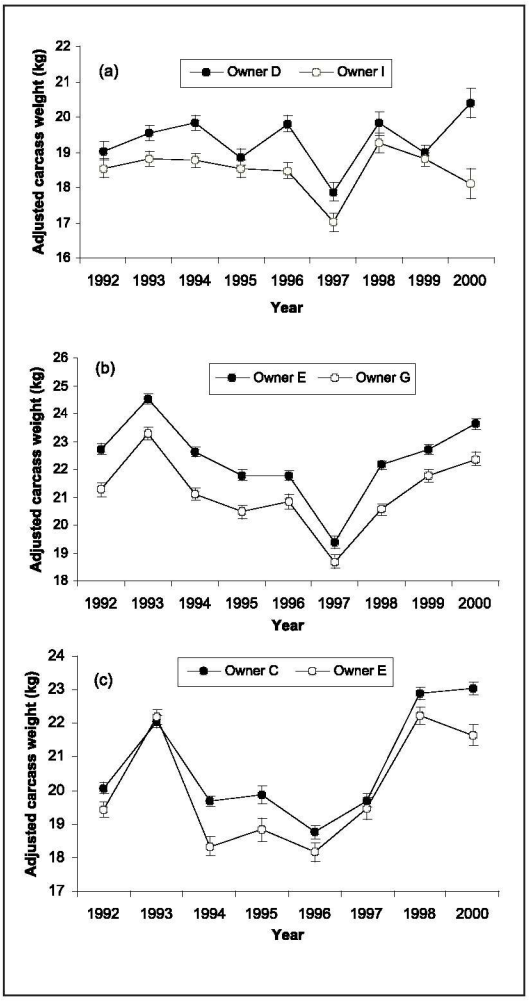

Fig. 2. Annual variation in autumn carcass weight (adjusted mean ± SE) of reindeer calves for the top (closed circles) and the bottom (open circles) reindeer owners in Essand (a), Riast/Hylling (b) and in Elgå (c) between 1992 and 2000.

Table 2. Mixed model assessing the effects of calf sex, owner and year on calf autumn carcass weight in Essand (a), Riast/Hylling (b) and Elgå (c). Year was fitted as random factor in the three models. Interactions are denoted by "x" between terms. We rejected terms with P value > 0.05.

Source	*df*	*F* value	*P* value
(a) Essand			
"Age"	1,6337	69.80	< 0.001
Calf's sex	1,7880	1065.86	< 0.001
Individual owner	8,7880	7.96	< 0.001
Calf's sex x Individual owner	8,7880	3.18	0.001
(b) Riast/Hylling			
"Age"	1,9881	148.47	< 0.001
Calf's sex	1,9892	1019.18	< 0.001
Individual owner	7,9892	28.32	< 0.001
Calf's sex x Individual owner	7,9892	1.73	0.098
(c) Elgå			
"Age"	1,4581	10.69	0.001
Calf's sex	1,4577	364.32	< 0.001
Individual owner	4,4577	10.56	< 0.001
Calf's sex x Individual owner	4,4577	1.30	0.269

to 2000 for owners with the lowest and highest values in Essand (Fig. 2a), Riast/Hylling (Fig. 2b) and Elgå (Fig. 2c). When including on these figures, least square means for the other owners (not shown here for clarity purposes), there seems to be a clear pattern of the same "good" and "bad" years within each district.

Additional analyses revealed that overall; autumn carcass weight was on average greater in Riast/Hylling (21.921 kg ± SE 0.3134), followed by Elgå (20.329 kg ± SE 0.3159) and Essand (19.105 kg ± SE 0.3137), all pair wise differences being significant (Tukey-Kramer adjustment tests; $P < 0.001$).

Discussion

We found that individual owners had a significant effect on the inter-annual variation in autumn calves carcass weights in Essand, Riast/Hylling and Elgå, despite the fact that reindeer are herded together. Also, Riast/Hylling showed highest performance in term of carcass weight as compared to Essand and Elgå.

The Sør-Trøndelag and Hedmark counties have been the sites for the pilot project aiming at improving the productivity and management strategies of reindeer production, and which has led to the recommended "sex-age and weight based slaughtering strategy". Ryast/Hylling, which was engaged in the development of this new strategy (Dag Lenvik, pers. comm.), is often referred to as the district following the "recommended strategy" more accurately as opposed to Essand and Elgå, where the strategy is however also used. This may be one reason, among others, why the average autumn calves carcass weight was higher in Ryast/Hylling than in Essand and Elgå, where the strategy is not that strictly applied. Indeed, different range conditions (forage quality for example, especially during summer) and different stocking rates (i.e. animals density) are two other important reasons for such difference in weight between populations. Furthermore, herders in Ryast/Hylling may be more consistent and/or stable with their management practice regarding the sex structure of their herd, as owner effect was sex specific only in Essand. It is worth mentioning that Sami herders in Sør-Trøndelag have productivity above the average as a result of more successful management regime (Reindriftsforvaltningen, 2001).

Our observations are in agreement with the presumption that some "owners" (i.e. their flock) may be having systematically higher average autumn weight than other over successive years within the same herd. The result in Fig. 2 shows a pattern of synchrony, which supports the view that individual herds are subjected to similar weather and range

conditions. This, therefore, strongly indicates that animals belonging to particular owners within a herd are subjected to specific "owner actions". Since owner autonomy occurs mainly during the slaughtering period, we interpret these results in the context of different strategy for slaughtering, i.e. the "individual selection strategy". This simply means that; either some owners apply the "recommended strategy" more accurately than others, or an individual owner will use his knowledge of the present flock, and his personal and inherited knowledge of optimal selection strategies, and thus at least modify the commonly recommended strategy proposed by the reindeer husbandry administration (Lenvik, 1988), when selecting animals to be slaughtered (with some exceptions, socio-cultural consideration may be more important for some herders). Individual knowledge, experience and "professional ability" may be important factors that determine how well a reindeer herder can select the best animals for breeding. We argue that because reindeer herding today is primarily an economic activity subjected to market forces, each owner will aim at maximizing his profit (immediate and long term), acting, as an independent economical decision-maker when choosing which animals should be slaughtered.

We therefore present this as a potential aspect of "Traditional Ecological Knowledge" in reindeer herding. Our argument on the potential role of individual strategy is supported by the fact that one of the most productive "owners" in Elgå is known to only rarely weigh his animals before slaughtering, but instead makes a "visual" selection based on his knowledge of his flock. Ferguson *et al.* (1999) reported that indigenous peoples possess knowledge about wildlife that dates back many generations. Moreover, herders' knowledge is reflected on herding practices and management (Fernandez-Gimenez, 2000), including sustainable harvesting regime (Turner *et al.*, 2000). We are aware that within one "driftsenhet", there could be animals owned by other persons, family members of the major "owner", and that they might have different slaughtering strategy. However, this will barely affect our findings as usually, more than 80% of the flock's animals belong to the major "owner" in three reindeer grazing districts.

Another explanation for the effect of individual owner may have been the use of specific patches by individual animals or groups of animals within the range. Indeed, optimal foraging models assume animals to have "rules of thumb" to decide where to forage, and large herbivores also appear to select patches and feeding sites to graze (Bailey *et al.*, 1996). Therefore, given that in ungulates social grouping strongly influences grazing behaviour (Dumont & Boissy, 1999), and that reindeer is one of the most gregarious deer (Geist, 1974), one would expect such a differential pattern in body mass variation even on sympatric animals, because individuals belonging to one owner may have a certain degree of affinity. This is not likely to be the main reason here given that in reindeer husbandry, more female are kept in the flock (about 80% in these three districts), and the affinity is maternal in reindeer. Indeed, herds in summer (mainly females and calves) will be composed of subunits groups (maternal lines) of animals from different owners. Moreover, flocks within herds are made at random during summer.

Conclusion

This study shows that individual reindeer owners through appropriate decision-making may improve the autumn weights of their calves, and hence the productivity of their flock (Reimers *et al.*, 1983; Lenvik, 1988; see also Reimers, 1997). Either they follow systematically the recommended strategy and their animals may have better performance, or the strategy in and of itself is not enough and appropriate adjustments, based on individuals' own knowledge of the flock, are necessary. This might be an important aspect of management strategies in order to optimise the production of reindeer meat, and hence promote the cultural significance of reindeer herding, in addition to meat production. It should further be investigated, using interdisciplinary approaches for example, whether the more "successful" owners draw on "Traditional Ecological Knowledge" in addition to the modern sex, age and weight-based selections criteria.

Acknowledgments

We gratefully acknowledge the financial support provided by the Norwegian Reindeer Husbandry Development Fund (to R. B. Weladji and Ø. Holand) and the Norwegian Research Council (to G. Steinheim). We thank Dag Lenvik and two reviewers for constructive comments on early versions that improved the manuscript. Bruce Forbes corrected the English language. Collection of the data was done with the collaboration of the Reindeer Husbandry Administration Office at Røros.

References

Bailey, D. W., Gross, J. E., Laca, E. A., Rittenhouse, L. R., Coughenour, M. B., Swift, D. M. & Sims, P. L. 1996. Mechanisms that result in large herbivore grazing distribution patterns. – *J. Range Manage.* 49: 386-400.

Dumont, B. & Boissy, A. 1999. Impact of social on grazing behaviour in herbivores. – *Production Animales* 12: 3-10.

Ferguson, M. A. D., Williamson, R. G. & Messier, F. 1998. Inuit knowledge of long-term changes in a population of Arctic tundra caribou. – *Arctic* 51: 201-219.

Fernandez-Gimenez, M. E. 2000. The role of Mongolian nomadic pastoralists' ecological knowledge in rangeland management. – *Ecological Aplications* 10: 1318-1326.

Gaillard, J.-M., Festa-Bianschet, M., Yoccoz, N. G., Loison, A. & Toïgo, C. 2000. Temporal variation in fitness components and population dynamics of large herbivores. – *Annual Review of Ecology and Systematics* 31: 367-393.

Geist, V. 1974. On the relationship of social evolution and ecology in ungulates. – *Amer. Zool.* 14: 205-220.

Gunn, A. & Skogland, T. 1997. Responses of caribou and reindeer to global warming. – *Ecological studies* 124: 189-200.

Klein, D. R. 1965. Ecology of deer range in Alaska. – *Ecol. Monogr.* 35: 259-284.

Kruuk, L. E. B., Clutton-Brock, T. H., Albon, S. D., Pemberton, J. M. & Guinness, F. E. 1999. Population density affects sex ratio variation in red deer. – *Nature* 399: 459-461.

Kumpula, J. 2001. Productivity of the Semi-Domesticated Reindeer (*Rangifer t. tarandus* L.) Stock and Carrying Capacity of Pastures in Finland during 1960-1990's. – *Acta Universitatis Ouluensis* Vol. A375, PhD thesis.

Lenvik, D. 1988. *Utvalgsstrategi i reinflokken.* PhD thesis. Reindriftsadministrasjonen, Alta. (In Norwegian)

Littell, R. C., Milliken, G. A., Stroup, W. W. & Wolfinger, R. D. 1996. *SAS System for Mixed Models.* SAS Institute Inc., Cary, NC, USA. 633p.

Milner, J., Elston, D. A. & Albon, S. D. 1999. Estimating the contributions of population density and climatic fluctuations to interannual variation in survival of Soay sheep. – *J. of Anim. Ecol.* 68: 1235-1247.

Reimers, E. 1983. Growth rate and body size differences in *Rangifer*, a study of causes and effects. – *Rangifer* 3: 3-15.

Reimers, E. 1997. *Rangifer* population ecology: a Scandinavian perspective. – *Rangifer* 17: 105-118.

Reimers, E., Klein, D. R. & Sørumgård, R. 1983. Calving time, growth rate and body size of Norwegian reindeer on different ranges. – *Arctic and Alpine Research* 15: 107-118.

Reindriftsforvaltningen 2001. *Ressursregnskap for reindriftsnæringen.* Reindriftsforvaltningen. Alta, Norge (In Norwegian).

SAS Inc. 1999. *The SAS system for windows*, release 8.01. SAS Inc.,Cary, NC, USA.

Sokal, R. R. & Rolf, F. J. 1995. *Biometry* – 3rd edition. Freeman and Company. USA. 887p.

Staaland, H. & Nieminen, M. 1993. World Reindeer Herding: Origin, History, Distribution, Economy. – *Proceedings: VII World Conference on Animal Production. Edmonton, Alberta, Canada June 28 – July 2.* Volume 1, Invited Papers: pp. 161-203.

Turner, N. J., Ignace, M. B. & Ignace, R. 2000. Traditional Ecological Knowledge and Wisdoms of aboriginal peoples in British Columbia. – *Ecological Applications* 10: 1275-1287.

Weladji, R. B., Klein, D. R., Holand, Ø. & Mysterud, A. 2002. Comparative response of *Rangifer tarandus* and other northern ungulates to climatic variability. – *Rangifer* 22: 33-50.

Manuscript received 14 December, 2001
accepted 5 August, 2002