AERIAL SEXING OF MOOSE CALVES AND IMPLICATIONS

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Abstract: Moose calves can be accurately and rapidly sexed during winter helicopter surveys by the white vulva patch in females and the silhouetted antler stubs in males. Preliminary results from this technique indicate that heavily hunted moose populations may produce substantially more female calves than male calves, while lightly hunted populations produce more male calves. Possible causes of sex ratio variations and management implications of these variations are discussed.

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Various types of age or sex selective harvest systems for moose (*Alces alces*) are in place in several jurisdictions in North America (Crichton and Timmermann 1982) including Ontario (Euler 1983). All of these systems direct more hunting pressure towards adult males than adult females. Some of the systems, as in Ontario, also direct hunting pressure at calves. The selective harvest systems have two main objectives: 1) to protect or increase the size and productivity of the herd by providing greater protection to the breeding segment of the population - particularly cows; and 2) to allow as many people as possible to hunt by directing heavy hunting pressure to the so called

unproductive components of the herd - either bulls or calves.

To maximize the yield from a selective harvest system, managers would like to know the allowable harvests from the particular age and sex categories in the system. Allowable harvest can be defined as:

ALLOWABLE HARVEST FROM CATEGORY	=	RECRUITMENT TO CATEGORY	+	NET IMMIGRATION TO CATEGORY	-	NON-HUNTING MORTALITY IN CATEGORY	-	DESIRED INCREASE IN CATEGORY

Recruitment is usually the largest component in the allowable harvest calculation, and therefore has an important effect on the size of the allowable harvest. Consequently, recruitment by sex is of particular interest in selective harvest systems. For example, if significantly more males than females are recruited as adults, then bulls could be quite resistant to overharvesting while cows could be very susceptible to overharvesting. A harvest system which does not adjust for differences in recruitment by sex could result in slow or declining rates of growth by overharvesting one of the sexes, loss of hunting opportunities by underharvesting one of the sexes, or reduced productivity by altering the sex ratio.

In moose populations, recruitment or net productivity can be estimated from the age structure of the harvest after adjusting for the differential vulnerability to hunting of calves and yearlings (Pimlott 1959, Simkin 1965). Recruitment can also be estimated from the number of calves found in aerial surveys (VanBallenberghe 1979). The recruitment estimates from aerial surveys are based on a more direct measurement and are thought to be more accurate than recruitment estimates from harvest statistics (Mercer 1974).

Separate recruitment estimates for males and females do not appear to have been calculated for any moose populations. Rather, recruitment by sex is generally assumed to be equal (Simkin 1965, Fraser 1976, Crête et al 1981). This assumption seems to be based on a few published studies of harvest data in which calf sex ratios were close to 1:1, such as Simkin (1965) and Fraser (1979). However, the sex ratio of the calf harvest in Simkin's study in northwestern Ontario was actually 114:100, and Fraser's study combined widely varying sex ratios for calf harvests from across Ontario to obtain an average of 108:100. In northcentral Ontario, the sex ratio of calves in the harvest has ranged from 67:100 to 153:100 (Timmermann and Gollat 1982). Therefore, harvest data seems to indicate that moose recruitment by sex may vary considerably.

The calf harvest by sex could be a useful index of moose recruitment by sex. However, if the harvest is a biased sample of the population, the sex ratio of the calf harvest may not reflect recruitment by sex. In addition, the number of calves sampled during harvest monitoring on individual management units is often small, which could reduce the accuracy of recruitment estimates. Also, some harvest systems do not permit the hunting of calves, which precludes this approach. Therefore, it would be useful to have a more direct measurement of recruitment by sex based on the number of calves of each sex estimated from winter aerial surveys. Aerial observability of calves should not be biased by sex, and aerial surveys should have a larger sample of calves than harvest returns - which should result in accurate estimates of recruitment for each sex.

The purposes of this paper are to: 1) describe a method for sexing calves during aerial surveys; 2) present some results obtained from this method; and 3) discuss the causes and management implications of variations in moose calf sex ratios.

STUDY AREA

The study area was Wildlife Management Units (WMU's) 32 and 34 located northeast of Lake Superior in northcentral Ontario (Figure 1).

WMU 32 includes 3962 km^2 to the north and east of Wawa. The topography of the area varies from rolling to hilly with numerous lakes and rivers. The vegetation is typical southern boreal forest with a mosaic of conifer, hardwood, and mixed wood stands. The dominant trees are white spruce (Picea glauca), jack pine (Pinus banksiana), black spruce (Picea mariana), white birch (Betula papyrifera), and trembling aspen (Populus tremuloides). About half of the Unit has been logged - mostly in small to medium sized clearcuts (< 2000 ha) for conifer sawlogs, but with some selective cutting for hardwood veneer and conifer sawlogs. Access is extensive from highways, railways, logging roads, and waterways. Therefore, hunting pressure is heavy. The winter moose density in WMU 32 was estimated at 0.19 moose/km^2 in 1985-86.

WMU 34 lies south of Wawa and includes 2010 km^2. The topography of the area is generally very hilly with numerous small lakes and streams. The vegetation is primarily of the Great Lakes forest type. Sugar maple (Acer saccharum), yellow birch (Betula alleghaniensis), white birch, and white pine (Pinus strobus) are dominant on the hills, while white spruce is dominant in the valleys. Most of the Unit has been selectively cut for veneer and sawlogs, with some small clearcuts (<200 ha) for sawlogs. Lake Superior Provincial Park makes up over two thirds of WMU 34. Vehicle access is restricted in the Park and poor road quality limits access in parts of the Unit outside the Park. In addition, almost half of the Park is closed to hunting. Consequently, hunting pressure in the

Figure 1. Ontario showing WMU's 32 and 34 study areas.

Unit is light to moderate. The winter moose density in WMU 34 was estimated at 0.34 moose/km^2 in 1984-85.

METHODS

Moose calves were sexed during the standard mid-winter aerial surveys conducted on WMU 34 in 1985 and on WMU 32 in 1986. Stratified random plot surveys were conducted according to the standard provincial format (OMNR 1981). The surveys were flown from the first week of January to the first week of February when the moose are generally still in open, early winter habitat and easily observed. Flying took place only on days with good visibility. The 2.5 X 10 km plots were flown intensively using transects 400 and 500 m apart and at an average altitude of 100 to 150 m. A small, 2-man Robinson R-22 helicopter was used to provide excellent visibility and a slow average speed of about 80 km/hour. The pilots and observers all had considerable previous moose aerial survey experience. All moose track patterns were searched until the observer was confident that all moose were accounted for.

Moose were aged as adults or calves based on body size and head length (Oswald 1982). Adults were sexed by antler presence, vulva patch occurrence, muzzle colour, and cow-calf behaviour (Oswald 1982).

Calves were sexed by the presence or absence of a vulva patch and the corresponding absence or presence of antler stubs. To do this, the helicopter was used to move the calf into the closest area with good visibility - usually a hardwood stand, an open mixed-wood stand, a cutover, or a marsh or lake. The occurrence of a vulva patch was then determined by flying low behind the calf. The helicopter was then moved

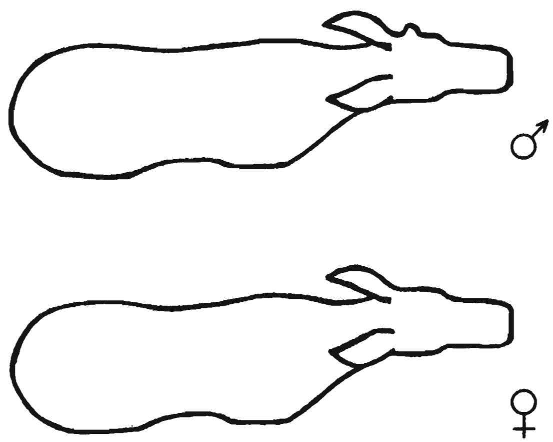

Figure 2. Aerial view of moose calves showing silhouetted antler stub on male.

up parallel and to the right of the calf, allowing the observer to look down on the calf from about 5 to 15 m above the tree tops and at an angle of about 20° to 30° out from the helicopter. At this height and angle, the left antler stub of male calves was clearly silhouetted against the snow just ahead of the ear, and often both stubs could be seen (Figure 2). It was also clear that other calves did not have these stubs (Figure 2). A determination of sex was not made until a clear view of both the rear and the head was obtained - which usually took no more than two attempts. If conflicting results were obtained from the two techniques, the observations were repeated. Sexing was usually completed in less than a minute. Care was taken not to chase calves for long periods which could cause exhaustion or permanent separation from the cow. If sex could not be determined quickly, we continued on with the survey and returned later for another attempt. If separation occurred the helicopter was used to direct the calf back to the cow.

RESULTS

In lightly hunted WMU 34, 69 calves were observed during the 1985 survey. Problems were encountered in sexing only 1 calf - it had a tan rather than a white vulva area but it did not have antler stubs, so it was called a female. A total of 36 males and 33 females were identified (Figure 3), for a ratio of 109:100. This is not a statistically significant difference from an even sex ratio (X^2 = 0.14, 0.75>p>0.50).

In heavily hunted WMU 32, 55 calves were observed during the 1986 survey. Of these calves, 2 could not be identified by sex because of the heavy conifer cover they were in. A total of 20 males and 33

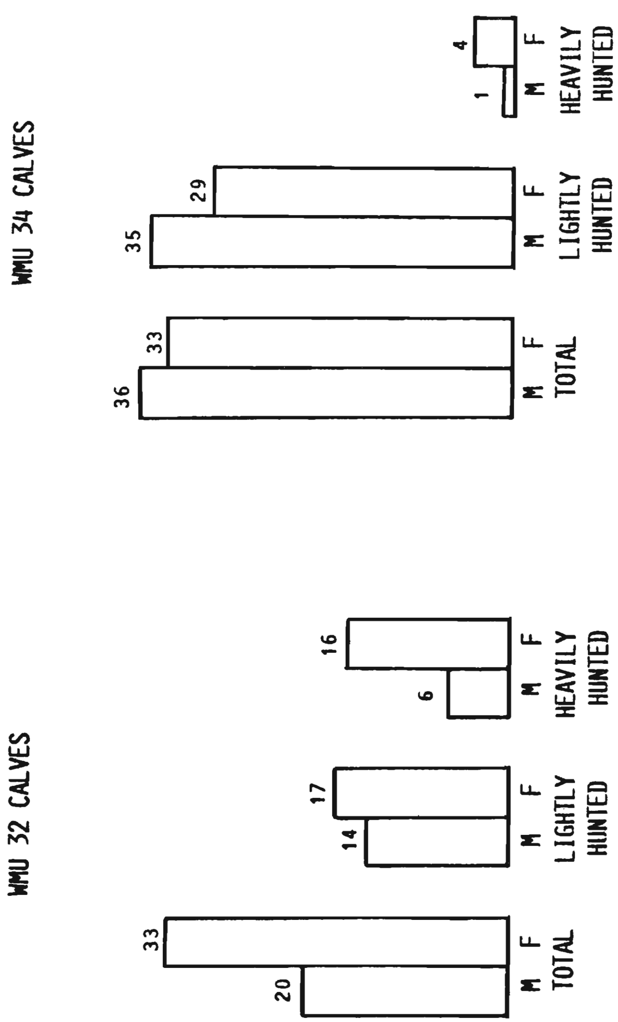

Figure 3. Numbers of moose calves by sex observed during aerial surveys of W.M.U.'s 32 and 34 in northcentral Ontario. Lightly hunted areas are more than 1 km from a heavily travelled road.

females were identified (Figure 3), for a ratio of 61:100. These results seem to indicate a departure from an even sex ratio, although not quite statistically significant (X^2 = 3.14, $0.10 > p > 0.05$).

Because female calves appeared to be dominant in the more heavily hunted WMU 32, an attempt was made to clarify this possible relationship by partitioning observations into heavily hunted and lightly hunted areas within both WMU's. Heavily hunted areas were defined as being within 1 km of a road which is heavily travelled by hunters during the moose season. The remaining areas were classified as lightly hunted.

The lightly hunted areas in WMU 32 had 14 male and 17 female calves (Figure 3), for a ratio of 82:100. This sex distribution is not significantly different from an even ratio (X^2 = 0.30, $0.75 > p > 0.50$). However, the heavily hunted portions of WMU 32 had 6 male and 16 female calves (Figure 3), for a ratio of 38:100. This sex distribution is significantly different from an even ratio (X^2 = 4.55, $0.05 > p > 0.025$).

Most of WMU 34 was classed as lightly hunted, and 35 male and 29 female calves were found in this area (Figure 3), for a ratio of 121:100. Again, this sex distribution is not significantly different from an even sex ratio (X^2 = 0.56, $0.50 > p > 0.25$). Only 1 male and 4 female calves were classed as being in a heavily hunted area in WMU 34 (Figure 3), for a ratio of 25:100. This sample is too small to test for statistical significance, but it does have the same trend as the heavily hunted areas within WMU 32.

When the data for both Units are combined, the lightly hunted areas have 49 male and 46 female calves - for a ratio of 107:100, and the heavily hunted areas have 7 male and 20 female calves - for a ratio of 35:100. These combined data indicate that calf sex ratios may be dependent on hunting pressure (X^2 = 5.59, 0.025>p>0.010). However, the sex ratio differences between lightly hunted and heavily hunted areas are not statistically significant within WMU 32 by itself (X^2 = 1.75, 0.25>p>0.10) or within WMU 34 (heavily hunted sample size too small).

The number of initial discrepancies between sex determination by vulva patch and antler stubs was not recorded, but was later estimated at about 5%. Various problems were encountered: snow and tan hair were mistaken for the vulva patch, and the vulva patch or antler stubs were not seen initially. However, all of the problems were resolved when the sexing procedure was repeated.

DISCUSSION

Aerial sexing of moose calves has been previously attempted using the vulva patch technique. Ellstrom (1965) and Mitchell (1970) noted that calves exhibited the presence or absence of a vulva patch, but they did not double check the sex of the calves they observed. Roussel (1975) identified 21 male and 31 female calves using the vulva patch technique during aerial surveys. During subsequent ground surveys, he found that 8 of the supposed females were actually males. He attributed this error to the occurrence of pale coloured hair in the ano-vulvar region of many male calves - which could be confused with the white vulva patch of females. Some calves in WMU's 32 and 34 would also have been wrongly sexed using only the vulva patch method. These errors seem to be fewer and more varied than in Roussel's study, but the reasons for these differences are not apparent. Nevertheless, it is clear that the vulva patch technique is not a completely accurate method of sexing

calves. However, errors from the vulva patch technique can be corrected by using the occurrence of antler stubs to confirm the sex.

The sexing of moose calves has apparently been attempted only rarely using the antler stub technique. Bonar (1983) tried to sex calves using this method but found that the antler stubs could not be reliably observed from the air, even on close inspection with a helicopter. However, the method outlined in this paper involves positioning the helicopter so that the antler stubs are silhouetted against the snow. The silhouetted stubs are relatively easy to see, whereas it is very difficult to see the unsilhouetted stubs against the dark head. Positioning the helicopter at a suitable angle does require good co-ordination between the observer and the pilot because the moose will be on the pilot's blind side. It may also be advantageous to use a small helicopter, such as the Robinson R-22, which has high maneuverability and good visibility for the pilot on the observer's side. Larger helicopters, such as the Bell 206 Jet Ranger, are less maneuverable and visibility is obscured by the large instrument console.

In terms of safety, aerial sexing of moose calves poses similar risks to other low level moose flying. The two pilots who participated in the study did not think the technique was unsafe.

Aerial sexing revealed an apparent predominance of female calves in heavily hunted WMU 32 but an almost even ratio in lightly hunted WMU 34. By dividing both Units into heavily and lightly hunted portions, the predominance of female calves becomes statistically significant in the heavily hunted areas. This apparent relationship between calf sex ratio and hunting pressure is supported by harvest data obtained from the provincial voluntary jaw return program. From 1983 to 1985, a total of

6 male and 32 female calf jaws were turned in from WMU 32, for a ratio of 19:100, which is significantly different from an even distribution (X^2 = 17.8, p<0.005). This harvest ratio is not statistically different from the aerial survey ratio of 38:100 on the heavily hunted part of WMU 32 (X^2 = 1.15, 0.5>p>0.1), but it seems to indicate that female calves may be even more predominant in heavily hunted areas prior to the hunt. During the same period, a total of 9 male and 8 female calf jaws were turned in from WMU 34, for a ratio of 113:100. This is not significantly different from an even distribution (X^2 = 0.06, 0.90>p> 0.75), and agrees with the aerial survey data.

Few studies were found which relate moose calf sex ratio to population status. In Sweden, Reuterwall (1981) found that the proportion of male calves in the harvest varied from 223:100 to 104:100 and was negatively correlated with the percentages of calves and bulls in the harvest and the total number of moose harvested - which could be interpreted as increasing hunting pressure. In Quebec, Crête (1982) found that the proportion of male calves in the harvest declined from 115:100 to 88:100 as the hunting season advanced into the peak of the rut - which was presumed to increase the hunting pressure on bulls. Franzmann (cited in Verme and Ozoga 1981) found that 2/3 of newborn calves were males in parts of Alaska where bulls were very heavily hunted. These studies seem to indicate that heavy hunting pressure on the entire population, rather than on bulls alone, may be related to a lower proportion of male calves. Also, moose densities were much higher in the Alaska study (Franzmann pers. comm.) and Sweden than in Quebec and this study. Therefore, the proportion of male calves seems to be positively related to herd density as well.

The reasons for sex ratio variations in moose calves are not well understood. A higher proportion of female young at low densities and male young at high densities appears to be the normal situation in white-tailed deer (Odocoileus virginianus), wolves (Canis lupus), and some species of voles and mice (Microtus and Peromyscus) (McCullough 1979). In white-tailed deer, male fawns have been found to be strongly predominant in populations with poor nutrition and at high density; and younger females, smaller litters, and females bred late in estrus also tend to produce more males (Verme 1983). There is also evidence that the first service of a buck each year produces predominantly male offspring, while subsequent breedings produce predominantly female offspring (Downing 1965). In mule deer and black-tailed deer (Odocoileus hemionus), there is some indication that fewer males are produced in larger litters and by previously bred females, but the relationship to range quality is conflicting (Robinette et al 1957). In North American elk (Cervus elaphus), there is some thought that more males occur on better range (Taber et al 1982). In Scottish red deer (Cervus elaphus), dominant hinds produce more male calves, which may be related to the hind's ability to obtain better nutrition (Clutton-Brock 1985). Note that the effect of nutrition in elk and red deer seems to be opposite to the effect in white-tailed and possibly mule deer. In humans, males are more often produced when conception occurs later in estrus , apparently because the pH of the female reproductive tract becomes less acidic and more favourable to the smaller y chromosome sperm that determines male sex (Shettles and Rorvik 1984). There is also some indication in humans that high sperm counts (increased by abstinence prior to conception) and deep penetration by the male may favour the smaller y chromosome sperm and result in a higher proportion of male offspring (Shettles and Rorvik 1984). In lemmings, inbreeding increases the proportion of female offspring (Reuterwall 1981). There is also other evidence that sex ratio may be genetically determined to some extent in cattle, mice, and man (Reuterwall 1981).

Some of the possible causes for sex ratio variation seem to fit the data from WMU's 32 and 34. The higher proportion of male calves in the lightly hunted areas agrees with observations from white-tailed deer, where more male fawns occur in higher density areas. This may be related to poorer nutrition in higher density areas. However, based on autopsies of road killed animals, there is no indication that any moose in WMU's 32 or 34 are nutritionally stressed. Therefore, nutritional differences may be subtle, or other density related factors may be more important in determining sex ratio. The lower proportion of male calves in the heavily hunted areas may be related to a lower proportion of older dominant cows in those areas - as in red deer, where less dominant hinds seem to have fewer male calves. Alternatively, the lower proportion of male calves in heavily hunted areas may be caused by a scarcity of large mature bulls with high sperm counts and deep penetration favouring the y sperm - as suggested for humans. A scarcity of bulls in the heavily hunted area would also require multiple matings which may favour the production of female calves - as in white-tailed deer. A higher incidence of inbreeding could also explain the higher proportion of female calves in low density areas. The sex ratio could also be genetically determined, but it is difficult to explain why adjacent populations are so different.

Some of the other possible causes for sex ratio variation do not

seem to agree with the data from this study. If younger females are more likely to produce male offspring, more male calves should occur in the heavily hunted areas where the age structure is likely to be younger - but this is not the case. Similarly, if male offspring are less likely in larger litters, more female calves should occur in lightly hunted areas where there are more cows of twin-producing age - again this is not the case. In addition, there is no indication that a scarcity of bulls has resulted in breeding late in estrus and subsequent production of male calves - because female calves predominate in the heavily hunted areas which should have the fewest bulls.

In the Alaska study of Franzmann, the high proportion of male calves was attributed to the cows being bred late in estrus because of the scarcity of bulls (Verme and Ozoga 1981). However, in the Quebec study, Crête (1982) suggested that heavy hunting mortality on bulls beginning in the peak of the rut may have limited most breeding to early in the rut and early in estrus, thereby resulting in more female calves. Reuterwall (1981) reviewed the possible causes for sex ratio variation and concluded that the sex ratio in moose is probably determined by complex interactions among a number of variables which may counteract or enhance each other. Certainly much more work is needed to determine the factors responsible for moose calf sex ratios under various conditions.

Although the causes of the variation in moose calf sex ratios are not well understood, the advantages of these variations are clear. At low densities, it is advantageous for moose to produce more female offspring to maximize their reproductive success. Resources are usually more abundant at low densities, which favours further reproduction by female offspring. Females are also less likely to emigrate from this favourable situation. Conversely, resources are usually less abundant at high densities, and male offspring are favoured because they are more likely to emigrate to an area with better conditions - where they can reproduce successfully. In white-tailed deer, it appears that males have greater reproductive success than females when carrying capacity is suddenly increased by fire or logging. However, in deer born after the increase in carrying capacity, females have higher reproductive success than males (McCullough 1979). Moose may have the same strategy to take advantage of improvements in carrying capacity.

MANAGEMENT IMPLICATIONS

Using aerial surveys to estimate the total number of male and female calves should result in more accurate estimates of the recruitment of bulls and cows. This should improve the accuracy of allowable harvest calculations, and the performance of selective harvest systems. Improvements should be most noticeable in areas with low densities and very high densities, where calf sex ratios are apparently most distorted.

Estimates of the number of moose calves by sex should also provide a better understanding of moose population dynamics. For example, moose populations and computerized population simulation models are very sensitive to changes in the calf sex ratio (Reuterwall 1981). Therefore, more accurate calf sex ratio estimates should improve our predictions about moose populations. Also, with accurate data on recruitment, harvest, and numbers of each sex, it is possible to calculate non-hunting mortality by sex - which is very difficult to

measure directly. This information would improve both our understanding of differential mortality by sex and population modelling results.

The sex ratio of moose calves may also indicate population status. A high proportion of male calves may indicate a very high density population with relatively light hunting pressure or heavy selective pressure on bulls. A high proportion of female calves may indicate a very heavily hunted, low density population. A relatively even sex ratio may indicate a moderate density area with light to moderate hunting pressure (or heavy pressure in Sweden).

Caution must be exercized in substituting calf sex ratios from harvest data for ratios obtained from aerial surveys. Although harvest data is easier and less expensive to collect than aerial survey data, harvest data may not be representative of the population. This could result in substantial errors in allowable harvest calculations and population modelling results. For example, the recruitment of females in WMU 32 would be severely overestimated if the calf sex ratio was assumed to be 19:100 from the harvest data rather than 61:100 from the aerial survey data. However, in WMU 34, the calf sex ratios in the harvest and the aerial survey are similar. This may indicate that harvest data could be substituted for aerial survey data in lightly hunted or evenly hunted areas, but not in areas with uneven hunting pressure. More work is needed to determine when aerial survey data is required and when harvest data is sufficient to determine calf sex ratios. However, if aerial surveys are being conducted to obtain population estimates, it requires little additional effort to sex calves and obtain accurate information on recruitment by sex.

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