DANISH REVIEW
of
GAME BIOLOGY

Edited by

Jagtfondets vildtbiologiske undersøgelser

and

Vildtbiologisk station, Kalø

Managing editors

R. Spärck
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Vol. 4, Part 1

Copenhagen 1959–63
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RESULTS OF PHEASANT MARKINGS IN DENMARK 1949-55

BY

KNUD PALUDAN

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INTRODUCTION

The results of Pheasant markings on the Kalø Estate during the years 1950–53 have already been published (*Paludan* 1958); another large number of pheasants were marked by the Station and released in other parts of the country. The present paper reports on the pheasants marked during the years 1949–55 and on the recoveries obtained until the end of 1958.

Since the period covered ends only little more than three years after the last release the next few years might be expected to contribute a good many recoveries. This is, however, not very likely: if the latest release shows a recovery rate comparable to that of earlier releases only another two recoveries can be expected, and the appropriate corrections for missing recovery have, furthermore, been introduced in the various calculations.

During the years mentioned a total of 14,294 marked birds were released while up to the end of 1958 1054 recoveries, or 7.4% were obtained. Among the recoveries 906, or 6.3% of the birds released, were obtained as killed birds (= 86.0% of the recoveries).

The material is very composite since not only are adults and juveniles involved but the releases took place in various parts of the country and often under very different circumstances. Add to this that shooting pressure and recovery rate varied widely between localities, a feature which particularly affects the juveniles. It is, therefore, not possible to carry the analysis to the same level of detail as was the case in the Kalø data mentioned above where the fate of the marked birds was much better known.

THE ADULTS

Since in most cases the adults were released under circumstances which were different from those pertaining to the released juveniles, and since, presumably, they stood a higher chance of surviving the period immediately after the release it is reasonable to consider the two categories separately.

A total of 4928 adults were released, the great majority during the months January to April. Among those were also a large number of birds which, at the

expense of the Game Fund, were released in such parts of the country where they could be expected to contribute towards an increase of the existing sparse population. These birds had therefore to face an existence under rather unfavourable conditions. Another, smaller, contingency of birds were released at other times of the year, e.g. in the early part of the summer after having been penned during the breeding period.

Among the 4928 birds were 1541 cocks (31.3%) and 2275 hens (46.2%) while for the remainder (1112 birds, or 22.5%) the sex was not recorded. On several occasions it was found that coworkers without the necessary technical training or insight in the principles underlying ringing experiments did not keep a sufficiently detailed record of the individuals marked. Their excuse must be that the marking had to take place at a time of the year when game farmers and hunters are busy attending to their birds which must be trapped, dispatched or released. This, however, does not fill any of the numerous gaps in our records: once the birds have gone we have no means of obtaining the required data.

The portion of birds of known sex contained 59.6% hens and 40.4% cocks, i.e. 1.5 hens to one cock. It can be assumed that the sex distribution was nearly the same throughout the material.

Recoveries.

A survey of release and recoveries is given in Table 1. Column b shows the number of birds released in individual years while the recoveries during subsequent years are given in column c. A few recoveries, the exact date of which could not be established, are entered in column f, while column g contains the total number of recoveries.

The 4928 birds released as adults resulted in 489 recoveries, i.e. 9.9% of the number released.

As regards the sex of the birds recovered we are somewhat better off in as much as the sex was recorded in 440 of 489 recoveries (90.0%). The percentage of males was 62.0, i.e. 1 cock to 0.6 hens.

Also the present material brought out the fact—already known from Partridge (*Paludan*) and Mallard (*Fog*)—that the recovery rate was very different in ringed and wingmarked birds since, obviously, wingtags are often overlooked. Of the present material of adult pheasants 4155 were ringed on release, they resulted in 448, or 10.8%, recoveries whilst 773 wingmarked gave only 41, or 5.3%, recoveries. Thus ringed birds produced 100% more recoveries than did the wingmarked birds. In Mallard and Partridge the percentages were 60 and 50

Table 1. Distribution of 4928 adult pheasants marked during 1949–55, and of 489 recoveries obtained up to end of 1958.

Marked		No. of recoveries during 1949–58										Correction for expected further recoveries							To-tal	Recoveries without reliable date	Total no. of recoveries	
Year	Num-ber	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958										No.	%
a	b	c										d							e	f	g	h
1949	192	7	2	0	0	0	0	0	0	0	0								9	0	9	4.7
1950	37		7	3	0	0	0	0	0	0	0								10	0	10	27.0
1951	650			22	11	1	2	2	0	0	0								38	2	40	6.1
1952	1432				123	29	5	3	0	1	0					0			161	4	165	11.5
1953	1150					81	12	5	1	2	1				0				102	1	103	9.0
1954	943						79	16	3	5	0			0					103	3	106	11.2
1955	524							32	14	6	1		0						53	3	56	10.7
Total marked: 4928		Recoveries in age group.....						351	87	20		12	4	2	0	0	0	0	476	13	489	9.9
		Corrected.....						351	87	20		12	4	3	0	0	0	0	477			
		Distribution of 1000 recoveries...						736	182	42		25	9	6	0	0	0	0	1000			
								1.	2.	3.		4.	5.	6.	7.	8.	9.	10.				
								Age groups														

respectively. It is therefore pointed out, once again, that wingtags should not be used except in those cases where, for some reason, it is impossible to use rings.

It seems appropriate to compare the recovery rate with that found in Partridge and Mallard, 2.8 and 16.7 respectively. A comparison can, however, only be made with several reservations because of the inherent differences in age distribution, sex distribution, marking technique and time interval between release and first shooting season. The shorter this latter is the higher is the likelihood of surviving until the first shooting season which contributes by far the largest number of recoveries. The best basis for comparison applicable to the material at hand is the following:

Mallard: 249 ringed adults resulted in 19.7% recoveries.

Pheasant: 4155 ringed adults resulted in 10.8% recoveries.

Partridge: 1492 "adults" (add. and juvv. released in xi) resulted in 3.8% recoveries.

Even on the basis of these figures one has to be cautious when making general comparisons. Thus it seems highly probable that the reporting frequency (the percentage of retrieved rings on which the release station receives notification) is better for Mallard than for Pheasant and Partridge because dispersal ranges wider in Mallard than in the two other species. The person who comes across a marked Mallard is more often ignorant of the point of release and, therefore, more anxious to supply information than is the sportsman who knows already that a marked Partridge was released in his own or his neighbour's field. Unfortunately, we have no means of estimating the importance of the varying reporting frequency for the recovery rate, hence the above premisses are not sufficient to draw the conclusion that the released mallards are exploited two times better than the pheasants.

It seems more justified to compare Pheasant and Partridge, since here the reporting frequency may be assumed to be of the same order. However, in addition to the sources of error already mentioned yet another factor must be taken into consideration, namely the proportion of recoveries which relates to birds actually exploited through shooting. So far as this aspect is concerned it has been found that 80% of the recovered pheasants but only 46% of the partridges had been shot. It would therefore seem that the rate of exploitation is even more different in Pheasant and Partridge than is indicated by the recovery rates, 10.8 and 3.8% respectively.

Mean annual mortality.

As already mentioned the rows of figures in Table 1, column c indicate the number of recoveries obtained for each year class during the year of release and the subsequent calendar years. The diagonal columns give all recoveries pertaining to each age group through all years, thus e.g. the column on the far left shows that all 7 year groups (a total of 4928 birds) resulted in 351 recoveries in the first age class, which corresponds to the calendar year of the release. The year group 1949 could thus have resulted in recoveries in each of 10 years when the study was brought to an end whereas the year group 1955 would only have been exposed to the risk of mortality during 4 years. In order that all year groups should have been able to provide recoveries during 10 years figures should also have been available in all diagonal columns falling within column d. By comparing, within each age group, the number of birds which have not yet had the opportunity to yield recoveries with the number of birds in previous year classes and the recoveries which have resulted from them it is possible to estimate, sufficiently accurately, the number of missing recoveries. Calculations show that the following 6 years, up to the end of 1964, are unlikely to result in more than one additional recovery. This missing recovery is entered in column d and has also been taken into consideration when the corrected distribution of recoveries on age groups was calculated. The 477 recoveries are distributed as follows on the year of release and subsequent years:

351 87 20 12 4 3 0 0 0 0.

Thus only the first two years contribute a fair number of recoveries while during subsequent years the rate of recovery is negligible.

If the shooting pressure and other causes of mortality were of identical intensity in all age groups the percentage drop in the recovery rate of subsequent year groups reflects a proportionate drop in the number of survivors from one year to the next. Where only one release is effected in just one place the rate of decline (causes of death) may vary between years and thus result in a sequence of recoveries which does not reflect a corresponding decline of the population of survivors. The fact that the releases reported on here took place over 7 years and in many different places has the effect of eliminating possible excursions from the average recovery rate. The steadily decreasing number of recoveries must also be an expression of a corresponding change in the initial population of released birds, and the only change that can be visualized to produce this result is that the population decreases in proportion to the recoveries or, in other words, that the percentage decrease in recovery rate reflects a similar percentage decrease of the population size.

On the basis of this assumption the mean annual mortality (M) in the population of released Pheasant is calculated in Table 2. This gives us:

$$M \pm S.D. = 71.1 \pm 1.8\%.$$

Table 2.

Mean annual mortality among adult pheasants, males and females, based on 477 recoveries from 4928 individuals released as adults.

Age-groups x	Nos. recovered in each age-group d_x	xd_x	
1	351	351	$\hat{s}$ (annual survival factor) = $1 - \frac{N}{\Sigma xd_x} = 0{,}2891$
2	87	174	S.D. = $(1 - 0.2891)\sqrt{\frac{0.2891}{477}} = 0{,}0175$
3	20	60	
4	12	48	Mean annual mortality rate:
5	4	20	$M \pm S.D. = 71.1 \pm 1.8\,\%$
6	3	18	
	N = 477	671	

For these calculations the first age group was considered in no way different from the subsequent age groups; this is, however, only partly true since the release process is accompanied by a certain measure of mortality which causes an increased mortality in the first age group, furthermore the birds were not released on 1 January but at different times during the year although mostly during the first months of the year. This circumstance has the effect that not all birds had the chance to produce recoveries during all of year 1. Through this latter circumstance the likelihood of obtaining recoveries during the first year is reduced and the effect of the mortality associated with the release to some extent counterbalanced. On the other hand the errors introduced through these causes seem not to be important; on calculating the mortality in each separate age group it is found to be 73.5 in the first and 69.0% in the second.

It may, however, be more appropriate to base the calculations on the number of birds actually shot, since by doing so the two complications mentioned above are eliminated and first year recoveries therefore directly comparable to later recoveries. One further advantage is gained by using this procedure: results based exclusively on birds killed are more easily compared with a material of

birds released as juveniles in which latter category the incongruity between first and subsequent age groups is still more pronounced than in old birds.

The 4928 birds released as adults resulted in 489 recoveries of which 389 were birds actually shot, i.e. 79.6% of the recoveries, hence 7.9% of the birds released as adults were reported shot.

On repeating the calculations of Table 2 but considering only birds shot the mean annual mortality is found to be 74.6% (S.D. = ± 1.9).

This figure refers to the mixture of males and females present in the material. It is however to be expected—at least in a species like the Pheasant where the possibility of applying different shooting intensity to the sexes exists and where, in addition, polygamy prevails—that the mean annual mortality is sex specific.

From among the 1541 birds reported as males on release 215 recoveries were obtained as birds shot, i.e. 13.9% of the number released. This is a much higher percentage recovery as birds killed than the 9.9% found when considering the entire material.

The distribution on age groups of the 215 cocks shot shows that the mean annual mortality among cocks released as adults must be

$$M_{\sigma} \pm \text{S.D.} = 78.1 \pm 2.5\%.$$

Among the birds released as adult the sex was stated for 2275 hens. They yielded 79 recoveries as birds shot which corresponds to 3.5% of those released. Comparison with 13.9% cocks shot shows that the shooting pressure applied to hens is much lower than to cocks, only about ¼ of the latter. The difference may, however, be somewhat exaggerated if, for some reason, people are more reluctant to supply information on hens than on cocks.

From the distribution on age groups of the 79 hens shot it can be calculated that the mean annual mortality among hens released as adults must be

$$M_{\varphi} \pm \text{S.D.} = 62.3 \pm 4.3.$$

There is thus a considerable difference in the mortality of cocks and hens. This also affords an explanation of the fact that the mean annual mortality was found to be 71.4% when the entire material and all recoveries are considered as against 75.1% when only the birds actually shot were considered. The explanation is that whilst the total number of recoveries included only 62% males the recoveries from shot birds had 72%, hence the shorter life span of the cocks affects more the latter than the former material.

The mean annual mortality agrees very well with the percentage found in the Kalø material, namely 75.0% among cocks and 57.6 among hens (*Paludan* 1958:5).

In the U.S.A. the mortality seems not to have been calculated on the basis of extensive ringing experiments covering several stations but in a population studied by way of winter trapping a mean annual mortality of 70% was found in cocks and hens combined (*Leopold* and coworkers 1943, *Buss* 1943). On the Pelee Island in Lake Erie where pheasants seem to live under particularly favourable conditions direct population analyses as well as ringing experiments made by *Stokes* showed a mean annual mortality of about 90% among cocks (including very intensive hunting) and about 45% among hens (including gentle hunting).

Mean expectation of further life (Y)

The rapid waning of recoveries and the high mean annual mortality have already indicated the short duration of a Pheasant's life. Disregarding the number of birds dying shortly after release the exploited birds enable one to calculate the mean life span for the birds still alive at the beginning of first shooting season. The calculations of Table 3 show that

$$Y_{\sigma} \pm \text{S.E.} = 0.804 \pm 0.050$$

which means that the cocks stood a chance of living for about $9^2/_3$ months after release.

Similar calculations for the hens give the result

$$Y_{\varphi} \pm \text{S.E.} = 1.105 \pm 0.120$$

or an expectation of further life of $13\frac{1}{4}$ months for the released hens. Since the recoveries of hens amount to only 81 the confidence limits are rather wide and the life span of hens is not significantly longer than that of the males. On using all recoveries, birds actually shot and dying for other reasons, the material comprises 269 cocks and 159 hens and the following results are obtained:

$$Y_{\sigma} = 0.745 \pm 0.037$$

$$Y_{\varphi} = 1.116 \pm 0.077$$

$$Y_{\varphi} - Y_{\sigma} = 0.371$$

$$m\,(\text{diff.}) = \pm\sqrt{(0.077)^2 + (0.037)^2} = \pm\, 0.0907.$$

Since $0.371 > 3 \times 0.0907$

the mean expectation of life for cocks and hens is probably real.

Table 3.

Mean expectation of further life, based on 217 males recovered shot.

Age-group x	Nos. recovered shot in each age group d_x	Nos. alive at the beginning of each age group l_x	Mean lifetime for birds dying in the age group z	$z\,d_x$	z^2	$z^2\,d_x$
1.	175	217	0,5	87,5	0,25	54,25
2.	34	42	1,5	51,0	2,25	76,50
3.	2	8	2,5	10,0	6,25	12,50
4.	1	6	3,5	3,5	12,25	12,25
5.	5	5	4,5	22,5	20,25	101,25
	217			174,5		256,75

Mean expectation of futher life $= Y = \frac{174.5}{217} = 0.8041$ years.

$SAK = 256{,}75 - \frac{(174.5)^2}{217} = 116{,}426$

Standard error = S.E. $= \pm\sqrt{\frac{116{,}426}{(216)(217)}} = \pm 0{,}04985$

True Value of Y: $0{,}654 < y < 0{,}954$

Based upon American studies *Leedy & Hicks* (1945) indicate an average life span of 9.85 months for cocks and 20.83 months for hens. Included in these calculations were only birds which had survived the first three months. Details of the calculations are not given, hence a more close comparison with the present data cannot be made; on the other hand they show, in agreement with Danish data, that the life span of a pheasant is very short. The larger difference between the mortality of the sexes in America may perhaps be explained through the non-existing or at least very gentle shooting of hens.

Composition of the population.

Assuming an average annual mortality of 78.1% an initial population of 1000 adults will decrease with time according to the sequence shown in Table 4 which

Table 4.

Annual decline of initial population of 1000 males and 1000 females assuming an annual mortality of 78.1% in males and 62.3% in females. Shown is also the percentage share of year groups of males and females.

Age groups	Males		Females	
	Alive at beginning of each age group	Percentage share of age groups in total population	Alive at beginning of each age group	Percentage share of age groups in total population
1	1000	78.1	1000	62.3
2	219	17.1	377	23.5
3	48	3.8	142	8.8
4	10	0.8	54	3.4
5	2	0.2	20	1.2
6	0		8	0.5
7	0		3	0.2
8	0		1	0.1
	1279	100	1605	100

shows that after five years the number has dropped to 2 and that it will have disappeared entirely during the sixth year.

The sequence also shows that of a population of 1279 cocks 1000 individuals will be in their first breeding period, 219 one year older and the subsequent age groups count of 48 – 10 – 2 and 0 individuals respectively. Expressed on a percentage basis this means that the two first age groups contribute 78.1 and 17.1% or a total of 95.2% of the entire breeding population. The older age groups only represent 4.8%.

The right half of the Table contains similar calculations for the hens. Due to the lower percentage mortality the initial population of 1000 individuals is still represented in the 6th, 7th and 8th age group up to which no cocks survived. However, also among the hens the two first age groups dominate the picture since they contribute 62.3 and 23.5%, or a total of 85.8% of the entire population of hens. The naturally occurring populations of hens as well as cocks show therefore a fairly low mean age.

Throughout these calculations cocks and hens have been considered separately and it is not possible to pool the sexes in the hope of obtaining a picture of the sex composition of the entire population or of the contribution of sexes to the

age distribution. The ratio between cocks and hens was not 1:1 in the initial population and from the material we can extract no information on the percentage survival of the sexes from hatching to first breeding season. We do, however, know that the annual percentage survival among adult birds is 21.9% among cocks and 37.7 among hens and on assuming the *ratio* between these percentages to apply to the older age groups as well as to the period covering juvenile life, first shooting season, and first winter 1721 hens per 1000 cocks will survive to first breeding period.

On the basis of these considerations it has been calculated, in Table 5, what a population of 4041 birds would look like as regards age groups and what would be the frequency of cocks and hens in different age groups. The entire population would show a cock to hen ratio 1:2.2 while in the first age group the ratio would be 1:1.7 and in the 5th group 1:17.5.

The conditions considered here will only lead to small differences in sex frequency but it is quite probable that the fundamental assumptions were erroneous. Thus it seems very likely that there is a greater difference in mortality among cocks and hens during the period from hatching up to first breeding period than during the next following years; it should be borne in mind that the

Table 5.

Calculated average composition of a population, assuming mortality to be 78.1% in males and 62.3% in females and the number of both sexes surviving up to first breeding season to be in same proportion as the mortality percentages.

Age groups	Nos. in each age group			Share of each age group in total population %	Share of sexes in each age group (%)		♂: ♀
	♂♂	♀♀	♂♂+ ♀♀		♂♂	♀♀	
1	1000	1721	2721	67.3	36.8	63.2	1: 1.7
2	219	649	868	21.5	25.2	74.8	1: 3.0
3	48	245	293	7.3	16.4	83.6	1: 5.1
4	10	92	102	2.5	9.8	90.2	1: 9.2
5	2	35	37	0.9	5.4	94.6	1:17.5
6	0	13	13	0.3	0	100	0:13
7	0	5	5	0.1	0	100	0: 5
8	0	2	2	0.1	0	100	0: 2
Total	1279	2762	4041	100	31.7	68.3	1: 2.2

birds have been through one shooting season where male mortality dominates the picture but not yet through a breeding season which may be assumed to incur heavier loss of hens than of cocks. The change in the ratio between sexes may well be greater than assumed in Table 5 (1000 cocks to 1721 hens). In order to obtain the ratio of 1 cock to four hens in the entire population 3200 hens per 1000 cocks must survive up to first breeding season provided that the annual mortality after that time can be assumed to be 62.3% among hens and 78.1% among cocks, the values found in the present material of ringed birds. Whether, under the given circumstances, a sex ratio of 1:4 can be attained seems somewhat doubtful since it presupposes a considerable difference between male and female mortality over the period from hatching to first breeding season; thus on fixing female mortality at 0 the male mortality over this period must be 68.6% in order to produce the end result of 3200:1000.

A sex ratio of 1:10 is often assumed to be advantageous but this ratio cannot be attained under any circumstances when the annual mortalities of males and females show no greater difference than the one found in this material. In spite of gentle shooting pressure on females or even no shooting at all the female mortality can only be reduced by a small factor, and one would therefore have to take a much heavier toll of the males probably amounting to a total of about 90% annual mortality or even more.

CHICKS

The marked chicks form a very heterogeneous material. The bulk of the chicks were released with mother hens at 5–6 weeks of age but several of them had been marked when younger. For the marking of these young birds wingtags were used, this was also the case with some birds released at an older age. The correct ring size for adult birds can be used for chicks which are 8 weeks old although it is recommended that they should be 10 weeks old at ringing; in many cases rings were used instead of wingtags for the older chicks released. The material comprises releases of several hundred chicks on single estates as well as many smaller releases, and they were located all over the country.

During the years 1950–55 a total of 9366 chicks were released, 7164 (76.5%) wingmarked and 2202 (23.5%) ringed.

Recoveries.

Table 6 lists the releases and the recoveries obtained until the end of 1958. The 9366 chicks released gave 565 recoveries which corresponds to 6.0% of the number released.

Table 6. Distribution of 9366 chicks and subadult pheasants marked during 1950–55, and of 565 recoveries obtained up to end of 1958.

Marked		No. of recoveries during 1950–58									Correction for expected further recoveries									Total	Recoveries without reliable date	Total no. of recoveries	
		1950	1951	1952	1953	1954	1955	1956	1957	1958												No.	%
Year a	Number b	c									d									e	f	g	h
1950	818	18	4	1	1	0	0	0	1	0										25	1	26	3.2
1951	2178		76	20	4	0	1	0	0	0										101	8	109	5.0
1952	2481			105	12	5	2	1	2	0										127	0	127	5.2
1953	1375				71	9	3	1	0	0										84	2	86	6.3
1954	806					58	7	1	1	0										67	0	67	8.3
1955	1708						110	15	15	8										148	2	150	8.8
Total marked: 9366		Recoveries in age group.....					438	67	29	13	2	2	0	1	0					552	13	565	6.0
		Corrected.....					438	67	29	13	2	3	0	1	0					553			
		Distribution of 1000 recoveries...					792	121	52	24	4	5	0	2	0					1000			
							1.	2.	3.	4.	5.	6.	7.	8.	9.								
							Age groups																

It is tempting to compare the percentage recovery to the total recovery of 9.9% obtained with adult birds in order to arrive at an estimate of the advantage gained by releasing adults in preference to chicks. A direct comparison is, however, biased because the conditions of recovery are different in the two groups. Thus the chicks suffer much higher mortality during the period immediately after the release than do the birds released as adults and when the persons who look after the chicks take much trouble to find all dead chicks and to submit the rings this age class will produce a large number of recoveries which do not represent an exploitation of the birds released—on the contrary. It must be said, however, that—during the present study the game-keepers have supplied information on dead chicks to a very limited extent.

Another bias which creeps into the material is caused by the fact that the birds released as adults consisted of 40% cocks and 60% hens while the sex ratio among the chicks can be assumed close to unity. Of course this will also affect the percentage recovery since among the recoveries cocks exceed hens by a factor of 2–3.

The only acceptable measure of the exploitation of the released birds is supplied by a comparison of the number of birds reported shot. It has already been mentioned that from among the birds released as adults 79.6% of the recoveries were birds actually shot and also that they represent 7.9% of the birds released. The released chicks yielded 565 recoveries among which number 516 (or 91.3%) were birds shot; they represent 5.5% of the chicks released.

The recovery of 516 birds shot, the yield of the released chicks, could have resulted from the release of

$$\frac{516 \times 100}{7.9} = 6532 \text{ adult birds.}$$

If we have been notified of the same percentage of recoveries of adult birds and chicks it can be assumed that only 6532 of the 9366 released chicks survived to be full grown. In other words this means that 2834, or 30%, would have died prior to the first shooting season. Of course, this percentage only gives the order of magnitude of the average value; we consider it, however, a reasonable estimate although individual cases may scatter within wide limits around this value. Should the percentage be biased in any direction the likelihood is that it is too low since the material had a larger percentage of cocks which, as already mentioned, result in a larger number of recoveries than do the hens. It can be mentioned that the Kalø material mentioned earlier enabled us to conclude "that between one third and one half of 8-week old chicks and between one half

and two thirds of one-week old chicks disappeared from the population before the first shooting season began" (*Paludan:* 11).

Of the released chicks only 5.5% were recovered shot, indeed a very small proportion; the true yield is, however, likely to be somewhat higher since we cannot assume that all marks recovered were submitted to us. As a matter of fact we know for certain that some of the persons who received large consignments of marks never submitted marks to us from pheasants which were killed or shot. In spite of detailed instructions given, several estates were only interested in getting information on the pheasants shot outside the estate while very little was contributed towards some of the more interesting aspects of the marking experiments.

Since so many of the large releases only resulted in a scanty and not very reliable body of data on the yield resulting from the released chicks it is not possible to discuss the size of and variation in yield; it should, however, be mentioned that during the last few years a very large number of marked chicks were released in a few selected places; it is hoped that the outcome of this experiment will be able to answer some of the problems which must be left open here.

As regards the possible size of the yield reference is made to my previous report on the pheasants released at Kalø. Chicks marked 6–8 weeks old were harvested to an extent of 20–30%; and those marked one week old to 12–14%. Since the yield depends on the suitability of the area for pheasants, on climate and on shooting pressure the percentages only represent rough guiding values.

So far as sex determination is concerned we are here in a worse position than with the material of adult birds. The reason is that practically all birds were marked at an age when the sexes could not be recognized, hence all that is known about the distribution of sexes comes from the recoveries, while for the adults information was also available from the marker.

The 9366 chicks released resulted in 516 recoveries of birds shot, only for one third of these, 136 cocks and 34 hens, were data on sex supplied. From these figures it would seem that four cocks were shot for each hen but since the remaining 346 recoveries could well comprise a larger percentage of hens too much importance should not be ascribed to the ratio 1:4, in particular because the recoveries from birds released as adults seem to point towards a ratio of 1:2 or 1:3.

The recovery of wingmarked and ringed chicks was as follows:

7164 wingmarked gave a total of 432 recoveries, or 6.03%,

2202 ringed gave a total of 133 recoveries, or 6.04%.

Thus the recovery is seen to be identical in the two categories, and in strong contrast to the data obtained from pheasants marked as adults; the result also contrasts with our experience on Partridge and Mallard where the recovery of wingmarked birds was much poorer than that of ringed birds. When the marking methods seem equally efficient among pheasant chicks I can see no other explanation than some "error" has crept into the data, and the most reasonable explanation would seem to be that a large number of chicks must have been ringed too young—before 10 weeks of age—and that, consequently, several rings came off shortly after ringing.

Mean annual mortality.

The ringing data do not enable one to calculate the mortality from release to first shooting season of the birds released as chicks. It will, however, appear from what was said above (p. 16) that comparison with birds marked as adults seems to indicate that about 30% of the chicks released must have died within this period.

Just like the recovery of shot birds marked as adults may be assumed to reflect the relative decline in number of survivors and thereby offer a basis for calculating the mean annual mortality the decreasing annual recovery rate of shot birds marked as chicks informs us of the mean annual mortality through the years following on the first shooting season.

A total of 511 shot birds were recovered, and the correction used above indicates that yet another recovery may be expected. The distribution of the 512 recoveries on first and following shooting seasons is as follows:

$$417 - 53 - 27 - 9 - 4 - 1 - 0 - 1 - 0 : (512)$$

Using the procedure of calculation shown in Table 2 the mean annual mortality is found to be:

$$M \pm \text{S.D.} = 76.0 \pm 1.6\%.$$

In the first age group the mortality is noticeably increased, 81.4% as opposed to an average of 58.4 during the next following age groups, a reasonable explanation of the discrepancy seems to be that young birds are more easily shot than older ones, although it should be noticed that the same tendency shows up also among the birds released as adults; they show a mortality of 76.6% during the first year against an average mortality of 68.9 during the succeeding years.

The total mean annual mortality of birds released as adults was 74.6% (p. 9) or practically the same as among the birds released as chicks (76.0%). For this

latter category the calculations also cover the adult age classes since they are based on the recovery of birds shot. Thus for the two quite different materials the mean annual mortality turns out to be of the same order, a fact which gives considerable support to the assumption that the calculated values give a true picture of the changes taking place in wild populations.

It would seem reasonable to use the chick material for a calculation of the sex specific mortality. However, the sex was unknown at release, and among the 511 recoveries it was only known for 166 individuals, 135 cocks and 31 hens; for cocks as well as for hens this small, and therefore unreliable, material leads to a mortality considerably below 76%, the percentage found for the entire material. This means that, for some reason, the recovery of sexed individuals is more common in the older age groups; the sample is, therefore, biased and cannot be used for the calculations.

DISPERSAL OF RINGED BIRDS

For 443 birds released as adults it was possible to estimate with reasonable precision the distance between the points of release and recovery. The data are summarized in Table 7, and it appears that no less than 398, or 90%, were recovered within a radius of 4 km from the point of release. The bulk of those were probably shot quite near to the point of release but since locations are most often approximate it has not been possible to further subdivide the range from 0 to 4 km. Only 36 birds, or 8%, were recovered from a distance of 4–8 km while only 9 more distant recoveries were obtained, and among them the greatest distance was 17 km from the point of release.

It appears that although pheasants released as adults may disperse rather widely from the point of release only few do so, furthermore there can be little doubt that the pheasants recovered from distant points were released in places not suitable for pheasants. The mean distance for all 443 individuals amounts to 2.4 km but it may be an overestimate since for a large number (309) the distance was "0–4", i.e. an average of 2 km which may be somewhat high, perhaps even a good deal too high.

Among the 443 individuals the sex was known in 397, 248 cocks and 149 hens. The cocks would seem to scatter more widely than the hens, since they show an average distance of 2.6 km as opposed to 2.1 km in the hens. Also among the hens the distance never exceeded 10 km while 5 cocks were recovered from between 14 and 17 km from the point of release.

Table 7.

Distance between points of release and recovery.

Distance km.	Numbers		Percentage	
	ad.	juv.	ad.	juv.
0–4	398	502	90	97
4–8	36	16	8	3
8–17	9	0	2	0
Total	443	518	100	100
Average distance km.	2.4	1.8		

As regards the birds released as chicks the distance can be estimated fairly accurately in 518 cases. Since 91% of all recoveries were obtained as birds shot (565) the material is not dominated by birds found dead near the point of release but by birds which have had the opportunity to spread. Furthermore, some of the birds were not recovered until one or more years after the release. Among the 518 recoveries no less than 502, or 97%, were obtained in places less than 4 km away from the point of release, at least 109 even from a distance of less than 1 km. Only 16 (3%) were recovered 4–8 km away. The mean distance is 1.8 km but, here again, this figure may be an overestimate. The sex is only known for 157 birds (121 cocks and 36 hens) and there seems to be no significant difference in the mean distance in males and females although it can be mentioned that no hen was recovered more than 6 km distant from the point of release whereas 3 cocks were recovered at 6–8 km distance.

It can hardly be doubted that birds released as chicks show a less pronounced tendency to disperse than do birds which were released as adults. This may partly be caused by a certain amount of fidelity to the habitat where the birds spent their age of growth and partly by having been released in more suitable places.

CAUSES OF DEATH AMONG THE RECOVERIES

It will appear from the above that all 4928 birds released as adults can now be expected to have died. For about 10% the cause of death is known, namely for

practically all of the 489 recoveries. We do not know what caused the death of the remaining 90%, and the cause of death cannot be inferred since our sample is biased: it represents a selection of those which were most easily spotted by man. Therefore, the birds shot represent a much higher percentage among the recoveries than they would do among all birds released, neither 80 nor 91% being a fair estimate of the proportion of released birds which are shot. On the other hand one should not go to the other extreme and consider the 390 recoveries (7.9%) all that has been shot.

Table 8.

Causes of death among pheasants recovered. Ad. means marked and released as adults; juv. as chicks.

Information on recoveries given by sender	Numbers		Percentage	
	ad.	juv.	ad.	juv.
Shot or found wounded	390	516	79.8	91.3
Caught	7	10	1.4	1.8
Found dead or dying	51	13	10.4	2.3
Killed by farm implement or cattle	12	3	2.5	0.5
Predators, incl. dogs and cats	10	10	2.0	1.8
Traffic	6		1.2	
Hitting obstacles	4	1	0.8	0.2
Drowned	1		0.2	
Only mark recovered	6	9	1.2	1.6
No information	2	3	0.4	0.5
Total	489	565	99.9	100.0

A summary of the information given on the individual recoveries is shown in Table 8 where birds released as adults and as chicks are considered separately. Among the birds released as adults the majority of those found dead or dying probably belong in the category "shot or found wounded". The fact that only 13 birds released as chicks were found dead or dying shows that to a large extent information has not at all been given on dead chicks.

Of the 15 individuals which were found killed by farm implement or stepped on by a cow the sex was known in 13 which all were hens. Far more pheasants than indicated by the Table will probably succumb in a similar way since only a small proportion of the pheasants killed e.g. during mowing is detected, and

the birds actually spotted are perhaps not always examined more closely by the farmer which means that at least some of the cases are not reported back to us. The importance of mowing as a possible source of death was studied in somewhat greater detail at Kalø in 1958. The grass field bordered on woodland; it harboured 24 nests, the highest concentration within an area of about 500 ha. Of the 24 hens 10 were killed during the operation, four directly, three had to be done away with while three escaped badly injured. Also several American studies confirm the danger to brooding hen pheasants of farm implements.

The chances of detecting the extent to which pheasants are taken by stray cats and dogs and other predators are relatively small, hence such cases will only be poorly represented among the recoveries and be much rarer than in the population as an entity.

SUMMARY

1. During 1949–55 a total of 14,294 marked pheasants were released, 4,928 adults and 9,366 chicks and subadults.

2. Up to the end of 1958 the birds released as adults had resulted in 489 recoveries (9.9 %) and those released as chicks in 565 (6.0 %).

3. A difference in the percentage reported back does not necessarily mean that they have been exploited to a different extent.

4. Among the birds released as adults 389 recoveries (79.6 %) were obtained as birds shot, i.e. 7.9 % of the number released. Among the birds released as chicks the corresponding figures were 516 – 91.3 – 5.5.

5. The mean annual mortality among adult birds was

   71.1 ± 1.8 % (all birds released as adults),

   78.1 ± 2.5 % for cocks and

   62.3 ± 4.3 % for hens.

6. The expectation of further life (y ± S.E.) was

   0.745 ± 0.037 years for cocks and

   1.116 ± 0.077 years for hens.

7. In order to attain a cock to hen ratio of 1:10 in the breeding population which under certain circumstances is considered favourable one would have to shoot cocks selectively until the annual mortality is increased to about 90 %.

8. About one third of the released chicks must be assumed to die prior to the first shooting season.

9. Wingtags are easily overlooked but it would seem that to some extent chicks are likely to lose rings.

10. 90 % of birds released as adults and 97 % of those released as chicks were recovered within 4 km from the point of release. The maximum distance was 17 km in the former group and 8 in the latter. Among the birds released as adults cocks seem to scatter within wider limits than hens.

11. Table 8 summarizes the causes of death among the recoveries but their relative importance in the entire population cannot be inferred from the data given.

LITERATURE

Buss, Irven O. 1946. Wisconsin pheasant populations. – Wisconsin Conservation Departments Publication 326, A–46, 184 pp.

Fog, Jørgen. 1958. Mærkning af opdrættede gråænder 1950–55. (Hand-reared mallards (Anas platyrhynchos) marked during 1950–55) – Danske Vildtundersøgelser *8:* 32 pp.

Leedy, Daniel L., & Lawrence E. Hicks. 1945. The pheasants in Ohio. – In W. L. McAtee: The ring-necked pheasant and its management in North America: 57–130.

Leopold, Aldo, Theodore M. Sperry, William S. Feeney, & John A. Catenhusen. 1943. Population turnover on a Wisconsin pheasant refuge. – Journ. Wildl. Mgt. 7 (4): 383–394.

Paludan, Knud. 1957. Ringmærkning af agerhøns 1950–54. (Partridges ringed during 1950–54) – Danske Vildtundersøgelser *7:* 27 pp.

— 1958. Some results of marking experiments on pheasants from a Danish estate (Kalø). – Danish Rev. Game Biol. *3* (3): 169–181.

Stokes, Allen W. 1954. Population studies of the ring-necked pheasants on Pelee Island, Ontario. – Ontario Department of Lands and Forests, Wildlife Series 4: 154 pp.