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Department of Animal Populations, Institute of Ecology, Warsaw

Head: Docent Dr. R. Andrzejewski

Bogumiła OLECH

REALIZED PRODUCTION, MORTALITY AND SEX STRUCTURE OF A PARTRIDGE (*PERDIX PERDIX* L.) POPULATION AND ITS UTILIZATION FOR GAME PURPOSES IN POLAND

(Ekol. Pol. 19: 617–650). The material used in this study was obtained during the period from 1965–1968 in several ways: from Partridges caught for export by trapping, during the purchase of shot partridges, by direct observations and by means of game census questionnaires sent out to members of the shooting public. Calculation was made of realized production and mortality in Poland, percentage of flock affected by shoots, indices of use made of areas covered by shoots, and percentage of population affected by shoots. This last percentage was compared with theoretical values of permissible utilization in the gradient of realized production, estimating actual utilization as below permissible level.

Sex ratio in a free-living population of Partridge was defined for different periods. A description was given of the mechanism forming the sex structure of a population and the effect on this structure of the utilization operations employed.

Some of the parameters describing shooting which are of importance to the population are presented.

Investigation was also made of variations in weight of young and adult Partridges during the annual cycle, particularly during the open season.

Contents

1. INTRODUCTION

The aim of the present study is to create theoretical bases for a rational system of utilizing a free-living Partridge population (*Perdix perdix* L.). For this purpose it was necessary on the one hand to investigate the basic population indices determining variations in numbers, such as reproduction and mortality, and on the other to learn something of the ecological specific properties of the most common way of using a Partridge population – shooting. Bearing in mind the possibility of future repetitions of this kind of analysis for game maganement purposes I have endeavoured to elaborate a method based mainly on the results of this utilization.

2. METHODS AND MATERIAL

Material was collected during the period 1965–1968 from the whole of Poland from the aspect of the following problems:

1. assessment of sex and age structure of a Partridge population in the field in winter,

2. assessment of sex and age structure of Partridges shot during the open season,

3. assessment of sex ratio of hatching chicks,

4. general regularities of Partridge shooting,

5. assessment of body weight of Partridges during the yearly cycle, in particular during the open season.

Ad.(1). Assessment of sex and age structure of the population under field conditions was made on the basis of trapping for export carried out by the Small Game Breeding Centres of the Polish Hunting Union and Ministry of Agriculture, and some of the shooting clubs, during the winter months (January-March). As neither the specific character of trapping[1] nor a knowledge of Partridges' behaviour during trapping operations appeared to offer any possibility of selective predominance of one of the sexes or of certain age groups, I took it for granted that the age and sex structure obtained from trapping catches reflects the actual relations prevailing in the population.

Sex was very accurately defined (only about 1% of the individuals could not be identified) on the basis of the generally accepted characters (colour of shoulder feathers and median wing coverts). Definition of age in winter when trapping was carried out, was limited to dividing the birds into two classes: individuals less than one year old and older birds. The generally accepted diagnostic character is the end of the I and II primaries, which is sharp in young birds and rounded in adults.

Number of Partridges examined obtained from trapping

Tab. I

Years	1966		1967		1968	
Sex \ Age	adult	young	adult	young	adult	young
♂♂	239	476	470	1481	107	158
♀♀	195	554	337	1520	53	155
Total	1454		3808		473	

Material obtained by trapping is given in Tab. I. In practice it very rarely proved possible to examine a large series of Partridges coming straight from the field and never so far kept in captivity (the daily ,,catch" never greatly exceeded 40–50 birds). Partridges which had been kept in pens for periods from a few days to two months were those most often examined. In order to avoid the possible selective influence of deaths of any of the groups during

[1]Trapping known as ,,square-trapping" consisted in automatic dropping of a net stretched on a frame over feeding partridges.

the time they were kept in pens all dead birds were examined in the same way as surviving individuals.

Losses with careful penning (not over-large groups, keeping individuals caught later separately from those already penned) are slight, about 2–5% during a month. Under unfavourable conditions, e.g. in large export stations where several thousand Partridges are often kept in temporary shelters, losses may be as much as 15%. As it was difficult to define sex and age in about 10% of the dead individuals (cases of trampling or partial cannibalism) I defined standard sex and age relations among the other dead birds and this standard was used for segregating dead birds which could not be identified by their plumage into the appropriate sex and age groups.

Ad.(2). Sex and age relations in shot Partridges were examined during the open seasons applying in Poland, that is, from September 21st to October 20th in 1965 and 1966, and from September 1st to October 21st in 1967 and 1968.

A trial questionnaire was sent to shooting men all over Poland in 1965, asking them to give the sex and age of shot Partridges. Instructions were enclosed with the form as to how to identify sex and age during this period. Out of a total of 161 forms sent out, 42 responses were received, 19 of which were rejected (the respondent either did not shoot, had not understood the instructions or gave only part of the data). The remaining 25 responses related to 1674 shot Partridges which included:

adulti ♂♂ – 371 immaturi ♂♂ – 493
adultae ♀♀ – 274 immaturae ♀♀ – 536

In the same year, in order to check the results of the questionaires, examination was made on September 17th of 595 Partridges at the Game Purchasing Station in Warsaw. As purchase price varies depending on the age af the Partridges I accepted as a principle inspection of the day's bag and not what was left at the purchasing centre. This principle was adhered to in all subsequent inspections.

In the following years inspections of Partridges at the purchasing centre was the only basis for findings. The results are given in Tab. II.

As the start of the open season was shiften from September 21st to September 1st in 1967 the opportunity occurred for examining the birds from the age aspect in three groups: current year's (about 3 months old), previous year's (about 1 year and 3 months old) and older birds (2 years 3 months old or more). The method for distinguishing birds in their second year of life from older individuals, based on the moult (O l e c h 1969), can only be used until the time moulting ends, that is at most until mid-September. An additional difficulty is created by the fact that males moult earlier than females, so that in practice only material from the first week of September can be taken as a basis (Tab. III).

Number of Partridges examined obtained from shoots

Tab. II

Years	1965		1966		1967		1968	
Age / Sex	adult	young	adult	young	adult	young	adult	young
♂♂	470	698	815	1099	1749	1726	126 222*	228
♀♀	326	775	581	1243	983	1676	73 123*	210
Total	2269		3738		6134		982	

*additional series of adult Partridges.

Effectiveness of method for assessing age in adulti Partridges in September

Tab. III

Date	3.IX		10.IX		17.IX	
Sex	Number of individuals examined	Percentage of individuals of identified age	Number of individuals examined	Percentage of individuals of identified age	Number of individuals examined	Percentage of individuals of identified age
♂♂	94	100	195	84	116	41
♀♀	63	100	70	87	76	68

Ad.(3). Sex ratio in hatching chicks was defined with the cooperation of the Experimental and Breeding Station of the Polish Hunting Union at Czempiń, where „hay-mowing" Partridge eggs, i.e. eggs collected during the hay harvest, are purchased and incubated and the chicks kept in pens. A large part of the chicks die during the post-embryonic period, mainly during the first few days of life. All the dead chicks were dissected to establish sex, and the survivors' sex defined on the basis of their plumage, enabling the ratio of males to females of the hatching chicks to be determined.

A total number of 324 individuals was examined in this way (Tab. IV). It proved impossible to identify sex in 33 (10.2%) of these on account of excessive maceration of the internal organs (the chicks were kept in 15%

formalin solution). They were treated as all being females, since the ovarium of young Partridges is colourless and far more delicate than the testes, which take on a dark-grey colour on staining, harden and are less susceptible to maceration.

Sex ratio in hatching chicks and young Partridges surviving until autumn with extreme significance of $p = 0.05$

Tab. IV

Number of individuals					
hatched		dead by September		surviving until September	
♂♂ 190	♀♀ 134	♂♂ 130	♀♀ 86	♂♂ 60	♀♀ 48
♂♂ : ♀♀ ≠ 1 : 1		—		♂♂ : ♀♀ = 1 : 1	

Ad.(4). In order to collect more detailed data on the character of shoots in Poland and the way shooting operations affect the population in the area, questionnaires were sent to shooting men in 1967 requesting them to keep a record during the approaching season and later to forward the following data: date of shoot, district, number of hours of shooting, number of Partridges in each flock encountered and number of Partridges shot in each flock.

In all 1920 quastionnaires were sent out, from which 583 responses relating to 707 shooting-days were received. Of these 89 questionnaires containing the reply „I did not take part in a shoot", and 42 questionnaires containing dubious or incomplete data, were rejected. The remaining data were supplied by 452 shooting men who took part in 656 shoots, encountered 36.775 Partridges in 3125 flocks and shot 5662 birds out of that number.

In view of the controversial opinions as to the reliability of material obtained by game censuses it must be emphasised that: a) participation in the game records was completely voluntary, b) only 30% of the persons asked to join did in fact take part, that is, persons who were willing and able to comply with its requirements and c) correspondence with shooting men participating in the game records forms evidence that the material obtained from the questionnaire is reliable, obviously with the degree of accuracy required from quantitative visual observations.

Additional use was made of material obtained from the game record questionnaire „Results of shooting for small game", which is sent out annually since 1969 to about 20% of the shooting men in Poland by the Game Animals Section of the Institute of Ecology, Polish Academy of Sciences. Part of the results of these records for 1967 have been published by Andrzejewski, Nowak and Pilipiuk (1968).

Ad. (5). Body weight was examined on material consisting of 130 Partridges shot in numbers of about 11 at a time, at monthly intervals in the Experimental Hunting District of the Institute of Ecology PAN at Dziekanów Leśny near Warsaw. Moreover in order to compare the weight of adult and young Partridges during the open season the birds were weighed at the purchasing centre. During the season of 1966 a total number of 264 individuals were weighed and in the season of 1967 – 1800 individuals.

RESULTS

3.1. Sex structure of the population

3.1.1. Hatching period

The starting point for examination of the sex structure of a population is to establish the proportions of the young generation hatching out. Among hatched Partridge chicks the ratio of males to females differs significantly from the ratio 1 : 1 ($p<0.01$) in favour of males (Tab. IV). If it is not assumed that all unindentified chicks were hens (see methods), this difference is even greater. It must therefore be taken for granted that Partridges hatch with an excess of males (approximately 142 ♂ : 100 ♀ or more) which agrees with data in literature on many species of vertebrates (Geiser 1923). The only data in literature in relation to Partridges (McCabe 1946, after Popławski 1962) reveal the reverse ratio of males to females, namely 47: 53%, which can be presented as 89:100.Unfortunately, this study is not available and thus it is impossible to establish on what material it was based and to what degree it can be relied upon.

Sex ratio among those individuals which survived up to the age of about 2 months, by which time it is possible to identify sex by means of the plumage, does not differ significantly from the ratio 1 : 1 (Tab. IV).

3.1.2. Trapping

Among young birds (less than 1 year old) the ratio of males to females in the area is 1:1. In 1966, 1967 and 1968 the figures were respectively: 476:554, 1481:1520, 158:155, giving a total of 2115:2229 (difference is not significant statistically and this did not alter up to the nesting period (Tab. V).

Sex ratio under field conditions (trapping) in Partridge up to one year old, with extreme significance of p = 0.05

Tab. V

Sex \ Age	7 months (January 1967)	9 months (March 1967)
Number of ♂♂	138	810
,, ♀♀	129	788
♂♂ : ♀♀	1 : 1	1 : 1

Sex ratio among adulti Partridges – trapped or shot

Tab. VI

Years	Shoots ♂♂ : ♀♀	Trapping ♂♂ : ♀♀
1965/1966	470 : 326 = 144 : 100	239 : 195 = 123 : 100
1966/1967	815 : 581 = 140 : 100	470 : 337 = 139 : 100
1967/1968	1749 : 983 = 186 : 100	107 : 53 –
Total	3034 : 1890 = 160 : 100	816 : 585 = 140 : 100

A similar ratio of males to females during the first autumn of the birds life is given by Blank and Ash (1962) for populations in the South of England and by Sekera (private correspondence) for Czechoslovakia.

Among adult birds (over 1 year old) a statistically significant excess of cocks is observed (Tab. VI). In the winter 1966, that is after the nesting season of 1965, the excess for Poland was on an average 23 cocks per 100 pairs, and in the winter of 1967 – 39.5 excess cocks. In the whole material obtained from trapping the ratio of adult males to females was 816:585, that is the average excess of adult cocks in this case is 39.5 per 100 pairs.

3.1.3. Shooting

Preliminary results (1965 and 1966) revealed a significant excess of hens among young Partridges shot (Tab. VII), which would indicate -with the 1 : 1 ratio found under field conditions – that shooting is selective in relation to

Sex ratio among shot immaturi Partridges in consecutive weeks of shooting season with extreme significance of $p = 0.05$

Tab. VII

Years	3, 10, 17.IX	24.IX, 1.X	8, 15.X	Total
	♂♂ : ♀♀	♂♂ : ♀♀	♂♂ : ♀♀	♂♂ : ♀♀
1965	–	493 : 536 $\neq$ 1 : 1 (questionnaire)	205 : 239 = 1 : 1	698 : 775 $\neq$ 1 : 1
1966	–	408 : 627 = 1 : 1	894 : 813 = 1 : 1	1302 : 1440 = 1 : 1
1967	663 : 621 = 1 : 1	609 : 694 $\neq$ 1 : 1	454 : 361 $\neq$ 1 : 1	1726 : 1676 = 1 : 1
1968	228 : 210 = 1 : 1	–	–	–
Total 1967 and 1968	–	–	–	1954 : 1886 = 1 : 1

females. Similar suggestions were made by Hell (1964), who gives the ratio of young cocks to hens shot in Czechoslovakia in August and September in the years 1959–1961 as 1:1.5, 1:1.3, 1:1.7. When the material collected was analysed in detail it was found that the excess of young hen Partridges in the bag occurs during the first week of shooting, that is, at the end of September. The ratios of cocks to hens shot in the Warsaw voivodship in consecutive weeks of shooting are given below:

25. IX. 1966 214 : 378 $\neq$ 1 : 1
2. X. " 153 : 182 = 1 : 1
9. X. " 209 : 151 $\neq$ 1 : 1 (in favour of ♂♂)
16. X. " 204 : 171 = 1 : 1

At the same time the data given by Hickey and McCabe (1951), obtained from shoots in October and November, reveal a sex ratio of 1 : 1 among young Partridge. This gave rise to doubt whether it is here in fact, a question of selective shooting of hen Partridges, or whether of mistakes in identifying the sex of the youngest birds. In the next year particular attention was paid to this point. It was found that error resulting in young hens being identified as males may in fact take place before the start of the first moult, when the shoulder feathers and median wing coverts in cock and hen Partridges defined as juvenis are uniform and are similar (although not identical) to the drawing of hens' plumage after the first moult (Fig. 1). As the median wing coverts are the feathers from which the first moult begins in young Partridges, sex can be

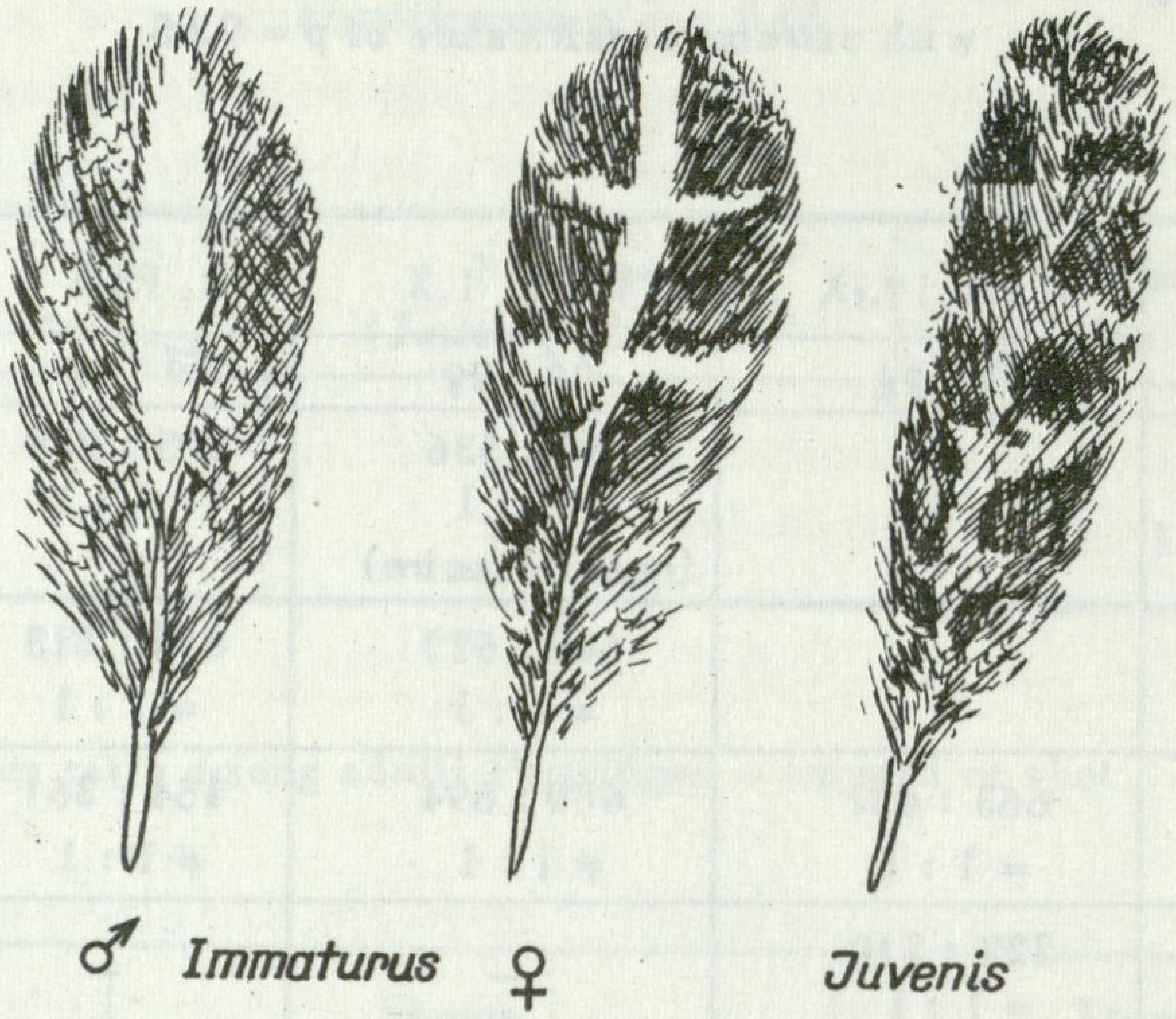

Fig. 1. Shoulder feathers in young Partridges in September

defined as early as in August in young birds from the first brood since moulting begins at the age of 38–40 days (Pojarkov 1955). Among young birds from the second brood the last individuals, not as yet moulting, may be encountered in mid-September. Thus August and the first half of September form the period when mistakes are possible. After September 15th the percentage of birds in which sex cannot be identified is very slight, e.g. on September 17th 1967 in Poznań out of 254 young birds only 20, i.e. 7.8%, had not yet begun moulting. Thus if the person carrying out the inspection is forewarned of the possibility of mistakes, he is unlikely to make them (of course rejecting individuals not yet moulting) and then the ratio of males to females among the young birds will be 1:1 (Tab. VII – material for 1967 and 1968). In the second half of September, however, an excess of hen Partridges is again obtained, and in the first half of October an excess of cocks which balances it. This is difficult to interpret, especially as the material would appear to be sufficiently plentiful. It is, however, important that when the open season (1st September – 21st October) is treated as a whole, the ratio of cocks to hens among the young birds shot is 1:1 ($p<0.01$).

Among adult Partridges shot during the open season the excess of cocks is greater than that revealed by field observations (Tab. VI). This excess is subject to variations in successive years but does not alter significantly over successive weeks of one season. Since it is difficult to imagine that some mechanism resulting in selective trapping of females is inevitable with the methods used for catching Partridges, while the selective shooting of adult cocks is known in game literature and has been convincingly explained by Bürgel (1958) (after Popławski 1962) on the basis of the distribution of cocks and hens in a flock in flight, the difference in ratios of 160:100 and 140:100 should be considered as a measure of the selective influence of shooting on adult cocks. This results in 20 additional cocks for every 140 cocks and 100 hens shot according to field proportions. This forms 12.5% of all shot cocks. Therefore if it is desired to form conclusions on sex ratios in a group of adult birds on the basis of material obtained by shooting, 12.5% of the cocks must be eliminated as an excess due to shooting itself.

3.2. Population indices

3.2.1. Realized production

As mortality among chick is very high, i.e. 70%, and varies greatly from year to year (Southwood 1967) and also chicks in any case usually fail to be included in utilization measures, it is generally agreed to take into consideration only those young birds which are approximately equal in size to adults, i.e. have survived up to their first September. This is what is known as realized production (Tab. VIII). For data from trapping this varies from 2.0 (calculated as ratio of immaturi to adulti) in 1967 to 3.7 in 1966. It is rather good in comparison with other countries, e.g. England, where the ratio of young to adults on the basis of observations in September was as follows for 1962–1966: 0.59, 0.59, 1.06, 0.62 and 1.43 (Eley Game Advisory Station Annual Reviews 1962–1965) and the figure 3.56 is considered as outstandingly favourable (Middleton 1935).

Realized production calculated on basis of trapping and shooting of Partridges

Tab. VIII

Year of hatching	1965		1966		1967	
Method	trapping	shooting	trapping	shooting	trapping	shooting
Imm.: ad. ♀	5.3	5.2	8.9	4.0	5.9	3.5
Imm.: ad.	2.4	2.0*	3.7	2.0*	2.0	1.4*

*with correction for selective shooting of ♂♂ ad. (explanation in text). Without correction successive values are: 1.7, 1.8, 1.2.

For purposes of comparison with values obtained from trapping realized production per adult hen and per adult individual was calculated from material obtained by shooting (Tab. VIII). In all three years calculated production is lower than that resulting from trapping, despite the fact that the necessary corrections were made for selective shooting of adult cocks. As reproduction is completely finished by the time the open season is reached and no further increase can take place there are two possible explanations of this phenomenon: 1) shooting has a selective effect not only on adult cocks but also to a certain extent on adult hens, 2) mortality is higher in autumn and winter among adult birds than among young. It is, however, difficult to find biological justification for the second possibility.

3.2.2. Age structure

Age structure is expressed in relative numbers of the different age groups. In the case of Partridges we are now able to present this structure with accuracy to one year of life, which in view of the annual reproduction cycle is fully sufficient. The only suitable period for obtaining the required data is August and the beginning of September, when it is very difficult to obtain sufficiently abundant material by means of trapping. It is for this reason that the material used as a basis originates from shoots (Tab. IX). Since, however, as shown in the section on sex structure, the results of shoots give 12.5% more adult cocks than hens than there are in reality, their number should be reduced by this correction (Tab. VIII). The difference between the number of cock and hens increases with increasing years of life, and thus the factor selecting hens is repeated each year.

Age structure of adult i Partridges assessed on basis of shooting

Tab. IX

Age	3.IX.1967	3.IX.1968	Total	Total with correction for selection ♂♂**
	♂♂ : ♀♀	♂♂ : ♀♀	♂♂ : ♀♀	♂♂ : ♀♀
One year old*	65 : 54	120 : 86	185 : 140	170 : 140
Older	29 : 9	78 : 29	107 : 38	98 : 38
Unidentified	0 : 0	24 : 8	24 : 8	8 : 8
Total	94 : 63	222 : 123	316 : 186	276 : 186

*one year old or over, age about 1 year and 3 months.

**correction for selective shooting of cocks was 12.5% out of 316 birds, that is, 40 birds. Included in correction: 1) all cocks from the unidentified age group in excess of the number of hens from this group, i.e. 16 birds, 2) remaining 24 cocks from the group of birds one year old or over divided in ratio 185:107 equal to ratio of these groups, that is 15 one-year old cocks and 9 older.

By adding to the data in Tab. IX one more class – immaturi – (calculated from average production during the nesting seasons of 1965–1967, expressing the ratio of immaturi:adulti in trapping and equal to 3.1)and treating the two sexes jointly, we obtain the following age structure: 1383, 310 and 136. I added values for 1967 and 1968 together here, as I did not require differences between them but only the most general measure of mortality. By converting the figures obtained per 1000 imm, we obtain the „life table":

1000, 224, 89

This exhibits a distinct agreement with the Danish „life table" (Westerskov 1951) and lesser agreement with the English „life table" (Jenkins 1957) obtained by means of individual marking:

Poland	100	22	9	
Denmark	100	20	4	0.8
England	100	38	11	6

The Polish „life table" is burdened by the error of the two (or perhaps more) last age classes being combined, but infortunately without individual marking it is imposible to define age over 2 years. In view, however, of the considerable amount of material available for this kind of „life table" (inspection of shot Partridges at a purchasing centre) and the small percentage only of individuals more than 2 years old (see below) the results obtained should be considered useful and sufficiently reliable.

The „life table" can also be calculated separately for the sexes if the ratio of cocks to hens among young birds is known to be 1:1. Results are as follows:

♂♂	1000	246	142
♀♀	1000	203	55

3.2.3. Average longevity

Average longevity for the two sexes jointly calculated by the classic method $\bar{t} = \frac{\Sigma n \cdot t}{\Sigma n}$ is 6.7 months. The result is slightly underestimated, since the two-year old class contains, in my opinion, only a certain small number of older birds which I was unable to segregate. I have therefore assumed that the average length of life of Partridges under Polish conditions is approximately 7 months, for birds which survived until their first September. If chicks were included in the calculated average the result would be far lower.

3.2.4. Mortality

Mortality calculated from the equation $q_x = \frac{d_x}{l_x}$ where q_x – mortality index in age class x, l_x – number of individuals beginning the age of x, d_x – number of individuals dying at age x, was 0.776 during the first year of life (between age classes immaturi-juvenis) and 0.558 in the second year (between age classes juvenis and adulti). The second value is slightly overestimated for the same reasons for which average length of life was underestimated. Average mortality among Partridges is approximately 60% annually.

3.3. Parameters describing shooting as a whole

Since the introduction by game authorities of close seasons for game the open season for Partridges falls in autumn. In Poland it was at first established as beginning on August 15th, after 1945 the open season was from September 21st to October and since 1967 from September 1st to October 21st every year. Taking the time of the first brood of Partridges as approximately June 25th and the second, supplementary period as July 15th-20th, this season is a period when almost all the young Partridges are able to fly (Partridges are able to fly by the fourth week of life – Jenkins 1961) althought the body weight of birds from the second brood is not as yet equal to those of adults. At that time the moult in both young and adult birds affects primaries and rectrices, which reduces their flying ability and causes better „sitting", which makes shooting easier.

Shooting consists in the area being flushed by one or more guns, sometimes one gun with a beater or a dog, and shooting as many birds as possible of the flocks encountered. Although there is a large number of varied principles established by custom for the number of birds to be shot and from which flocks, such principles are often contradictory and as there are no hard-and-fast regulations in force in this matter I shall not take them into consideration here. As it is easier to find flocks and track wounded individuals it is recommended that a dog should be used when shooting, and yet sportsmen using dogs are rare. This is confirmed by the questionnaire responses, which show that out of 452 shooting men only a few stated that they used a dog for shoots. Shot Partridges become the sportsman's property and there is no obligation to sell them at the purchasing centre. Even so a large part of the bag, i.e. 35.8% (Tab. X) reaches the purchasing centre. Such material can thus be considered as fully representing the whole of a given bag.

Percentage of Partridges purchased from shooting men
in relation to total bag

Tab. X

Years	Number of shot Partridges*	Purchased Partridges**	
		number	percentage
1965	411 722	146 603	35.6
1966	654 772	222 128	33.9
1967	558 385	213 759	38.3
Total	1 624 879	582 480	35.8

*Andrzejewski and Nowak 1966, Andrzejewski, Nowak and Pilipiuk 1967,1968.
**data obtained from „Las" United Non-Timber Forest Products in Warsaw.

In addition advance planning for Partridge shooting, such as, e.g. its duration, or planned number of birds to be shot, such shooting has a large number of its „own" indices, based on tradition, on average shooting skill and on the biology of Partridges in a given period. These are factors of great importance to the general extent of shooting, and often modify planned number of birds for shooting despite, or even contrary to, the recommendations of game laws. A knowledge of these factors, even if some of them did not at the given moment visibly affect the number of birds planned to be shot, would seem essential for planned game management.

Some of these factors will be presented on the basis of the questionnaire responses supplied by shooting men in 1967, in which year the open season lasted from September 1st to October 21st. During this time 67.4% of the shooting-days took place on Sundays. The distribution of the number of shooting-days in successive weeks of the season is significant (Tab. XI). On the basis of individual shooting (group shooting, as being few in number and similary distributed in time, were excluded as it was difficult to establish a comparable unit: 1 shoot, or 1 person shooting) it can be said that over 50% of the shooting-days took place in 1967 during the first half of September. As there was relatively low realized production that year this can be partly explained by limitation of numbers of birds shot after first and second Sunday of open season. The experience of purchasing centres shows, however, that this unfavourable (see below) tendency prevails in other years also.

One of the purposes of the questionnaire was to investigate the degree of utilization of a population. The simplest measure of such utilization is the ratio of the number of birds removed from a population (shot) to the number living in the area before utilization. If, however, the materials are to refer to large areas and it is impossible to establish the numbers present in an area, a search must be made for a different measure. For species living in groups this measure can be the average percentage of birds shot from one flock, on condition that the percentage of flocks encountered by shooting men in relation to all the flocks in the area is known. If each encounter of the flock is treated separately in this connection, even if it is a flock already shot at, it is possible to draw fairly accurate conclusions as to the utilization of the whole population from the utilization of the flock. With the currently used methods of assessing numbers this method, if generally used, would appear to be far more accurate than the classic one.

Thus the initial value for defining the degree of utilization of the population will be the percentage of Partridges shot from each flock encountered (Tab. XI). During the whole open season it fluctuates only very slightly (14.5%

Number of shooting-days, average size of flocks encountered and degree of utilization of a flock during the open season

Tab. XI

Date	September				October		
	1–9	10–16	17–23	24–30	1–7	8–14	15–21
Number of shooting-days	206	129	97	68	38	34	25
% of shooting-days	34.4	21.7	16.2	11.4	6.4	5.7	4.2
Average size of flocks encountered	10.2	11.1	10.7	9.9	10.1	10.0	10.5
Number of flocks encountered	1124	613	530	380	213	157	113
Percentage of individuals shot in each flock encountered	15.2	14.9	15.7	15.0	14.5	14.0	10.3

to 15.7%) and only during the last week falls to 10.3%. This explains the unwillingness of shooting men to shoot in October, when such operations are, as it were, less effective. It appears, however, that this is not due to decreased numbers in a floock and dispersal of the Partridges, as is often considered to be the case, since the average flock size in successive weeks of shooting (Tab. XI) remains practically unchanged.

Average utilization of a flock provides information on the percentage of Partridges shot only among flocks encountered by the guns. In order to calculate real utilization of a population it is necessary to base finding on certain estimated data also, but despite this the result will be interesting, since there are absolutely no attempts at estimating real utilization of Partridges in Poland.

Calculation was made from the responses to the questionnaire on Partridge shooting of the average dutarion of one shooting-day which varies very slightly (Tab. XII), and on an average for the whole of Poland is 4.5 hours. Knowing from the census „Results of shooting small game" the number of guns shooting Partridges in different voivodships and the number of their shooting-days, calculation was made of the number of hours of shooting in each voivodship. On an all-Poland scale this is 329–630 hours. The problem then arises as to how many hectares can be covered during this time. As the great majority of Partridge shoots take place without dogs it can be assumed on the strength of practical experience that a shooting man moves 3 km within an hour, flushing all the Partridges from a strip not wider than 50 m. Thus within an hour he flushes 15 ha. As shooting men search for places in which the density of Partridges is greater during this period, such as root crop fields and green forage crops, a further 25 ha was added to each 15 ha as a safety margin and possible area from which the birds might move to the flushed root and greenstuff crops. This area was estimated on the basis of data in the possession of the Chief Census Bureau (Główny Urząd Statystyczny 1968) on the area of sown crops in Poland in 1967, and parts of the crop timetable given by J e z i e r s k i (1969). In this way the area assumed to be capable of being covered by 1 shooting person within 1 hour was 40 ha. If this assumption is accepted it is possible to proceed to the number of hectares covered by shooting in each voivodship. The next complication consists in the fact that shooting operations did not always include the whole of the area available, or conversely, repeatedly covered the same areas so that taken jointly the results obtained come from a different number of hectares than the area covered by established shooting areas in a given voivodship. In order to avoid this complication calculation was made of the shooting index for field shoots for the different voivodships.

$$\text{Shooting index of the area} = \frac{\text{ha of area covered by shooting}}{\text{ha of field shoots}}$$

For this purpose I used the area of field shoots in Poland given by the Central Board of the Polish Hunting Union (Zarząd Główny Polskiego Związku Łowieckiego 1966).

In general therefore the shooting index of the area (a) is:

$$(a) = \frac{40\ \text{ha/hour} \cdot (b) \cdot (c) \cdot (d)}{(e) \cdot (f)}$$

Population utilization indices and

Voivodships	Average duration of a shooting-day in hours	Number of participans	Average number of shooting-day per a participant*	Area of shoots rented in thousands of hectares**	% of field shoots
Kielce	5.0	1924	4.0	1 593	75.4
Łódź	4.4	2417	4.0	1 529	82.2
Warszawa	4.6	4373	2.5	2 668	80.9
Katowice	4.5	2016	2.6	935	69.9
Opole	4.7	1197	2.3	762	74.4
Lublin	4.8	1580	2.5	2 051	79.3
Bydgoszcz	4.6	2175	2.5	1 673	77.3
Rzeszów	5.6	822	1.9	548	68.3
Poznań	4.7	3010	2.6	2 276	77.5
Kraków	4.4	1975	2.8	1 289	73.3
Ziel. Góra	3.4	638	2.0	1 065	56.0
Gdańsk	4.2	933	2.7	911	74.3
Wrocław	4.6	2156	2.1	1 466	73.0
Białystok	3.6	578	1.8	2 026	73.7
Olsztyn	3.7	259	1.6	1 846	73.3
Szczecin	2.9	472	2.1	996	71.8

*Andrzejewski, Nowak and Pilipiuk 1968.

**data of General Board of the Polish Hunting Union – Zarząd Główny Polskiego Związku

***index for the Olsztyn voivodships Gdańsk and Białystok.

where: (b) – mean duration of one shooting-day (c) – number of shooting men in a given voivodship (d) – average number of shooting-day per 1 shooting man (e) – area of established shoots (f) – percentage of field shoots.

This index (Tab. XII) fluctuates fairly considerably over Poland. Its absolute value is of course approximate. Generally it is 0,6 in voivodships with a smaller Partridge population, but exceeds 1.0 in voivodships where these birds are more numerous. The average value for the whole of Poland is 0.69.

As we know the percentage of Partridges shot in relation to those encountered in each voivodship, calculation can next be made of what percentage of the Partridges living in the area is formed by those shot and further – what are their absolute numbers in the area (g):

absolute number of Partridges living in Poland

Tab. XII

Shooting index for area	% of Partridges shot among those encountered	% of Partridges shot from those living in established shoots	Number of Partridges shot in established shoots in 1967	Total number of Partridges in established shoots in 1967
1.27	16.3	20.7	78 800	381 000
1.32	16.6	21.9	101 000	462 000
0.94	19.3	18.1	106 900	591 000
1.83	15.1	27.6	35 800	130 000
0.91	19.9	18.1	12.700	70 000
0.47	14.7	6.9	29 900	434 000
0.78	16.4	14.3	34 000	238 000
0.33	15.6	5.2	8 600	165 000
0.84	10.6	8.9	67 700	761 000
1.04	12.8	13.3	32 000	241 000
0.29	8.8	2.5	6 600	264 000
0.63	13.2	8.3	11 200	136 000
0.79	10.5	8.3	21 600	267 000
0.99	9.0	8.9	5 300	60 000
0.05	–	8.6***	2 500	29 000
0.16	6.7	1.1	3.200	291 000
0.69	14.8	12.3	557 800	4 520 000

Łowieckiego 1966.

$$(g) = \frac{(i) \cdot 100}{(a) \cdot (h)}$$

where: (a) – shooting index of the area, (h) – percentage of individuals shot of all those encountered, (i) – total number of individuals shot in a given voivodship (Tab. XII). Even more reliable is calculation of density per 100 ha, but in the case of Partridges the character of plant cover and kind of agricultural practice are of such a great importance that extreme differences in density can be found within small areas. It would thus appear unprofitable to present the average density of Partridges on a voivodship scale in birds/ha, and even, particularly for voivodships more differentiated in respect of Partridge habitats – totally incorrect. As a rough guide it can be stated that in the central voivodships, which are more uniform in respect of density of Partridge, this figure is 20–30 birds per 100 ha in September.

Connection between density of Partridges and degree of utilization of a flock and its size

Tab. XIII

Voivodships	Number of Partridges shot per gun shooting--day* (measure of density)	Average size of flock	Percentage of individuals from 1 flock (utilization)
Kielce	12.5	9.7	16.3
Łódź	11.9	10.8	16.6
Warszawa	11.1	9.5	19.3
Katowice	9.4	10.6	15.1
Opole	9.0	9.9	19.9
Lublin	7.7	12.0	14.7
Bydgoszcz	7.5	9.9	16.4
Rzeszów	6.5	11.4	15.6
Poznań	6.4	9.8	10.6
Kraków	6.1	11.8	12.6
Zielona Góra	5.0	10.9	8.8
Gdańsk	4.9	9.0	13.2
Wrocław	4.2	9.9	10.5
Białystok	4.0	12.7	9.0
Olsztyn	4.0	8.7	–
Szczecin	3.0	11.8	6.7

*Andrzejewski, Nowak and Pilipiuk (unpublished data).

A measure of density of a certain kind can be formed by the average number of Partridges shot by 1 person per 1 shooting-day (Tab. XIII). Data are taken from the questionnaire responses „Results of game shooting during the open season of 1967/68" (Andrzejewski, Nowak, Pilipiuk, unpublished data). The best results were obtained in the central voivodships (Kielce, Łódź and Warsaw voivodships). As the average size of flocks in these voivodships is not greater than in the remainder, the good shooting results obtained may be due to the considerable density of the flocks there or their utilization. The latter of course takes place but is not sufficient to account for the large bags, since for instance in the Kraków voivodship exploitation of a flock is only 1/5 smaller than in the Kielce voivodship (12.8% as compared with 16.3%) and the bags obtained by shooting men are twice as small. Poland as a whole can be divided into three regions in respect of Partridge density: central, with the highest density (corresponding approximately to the Kielce, Łódź and Warsaw voivodships), a region with medium density forming a wedge from the south-east to the north-west (Katowice, Opole, Kraków, Rzeszów, Lublin, Bydgoszcz and Poznań voivodships) and the poorest areas, lying in the north and west (Wrocław, Zielona Góra, Szczecin, Koszalin, Gdańsk, Olsztyn and Białystok voivodships).

The high percentage of birds shot in relation to its number in the area in voivodships with a good Partridge population is remarkable (Warsaw voivodship – 18.1%, Łódź – 21.9%, Kielce – 20.7%). Voivodships with high degree of utilization of the Partridge population include the Opole (18.1%) and Katowice (27.6%) voivodships.

Generally 12.3% of the head of Partridge in the area is shot, and thus with a total number of birds shot of 557.800 (Andrzejewski, Nowak, Pilipiuk 1968) the head of Partridge in Poland in established shoots before the open season of 1967 was 4520 thousand birds, and in all open areas, which form about 4000 thousand ha more – approximately 5500 thousand birds.

Comparison of results of individual and group shooting

Tab. XIV

	Shooting	
	individual	group
Average number of Partridges shot per 1 shooting-day by 1 participant	$7.\overline{3}$	3.8
Average percentage of Partridges shot per flock	12.3	20.7

The influence of the way in which shooting is carried out on the extent and way in which populations are utilized remains to be discussed. Of the two currently practised shooting methods: individual and group, it is the second which is less popular (numer of shooting men multiplging by number of shooting-days held, since only this figure is comparable for the two kinds of shooting practice, is 535 for individual and 172 for group shooting). In the first group a gun achieves results almost twice better than in the second, and simultaneously shoots a smaller percentage of the birds in the flocks encountered (Tab. XIV). Group shooting, although less effective for the individual guns, remove a higher percentage of birds from the flock and hence is to be recommended in cases in which a given selective effect on the flock is desired, e.g. shooting of a large number of juveniles, which is shown by Bürgel's plan (Bürgel 1958, after Popławski 1962).

3.4. Body weight of Partridges

The mean weight of cocks and hens based on weighing of 10–15 Partridges monthly is given in Fig. 2. Maximum body weight is attained by Partridges in late autumn and winter[2] (November, December, January) and they are about 10% lighter during the open season. This is connected with the energy expenditure during the moult immediately preceding the open season (Blumental 1967) and also with a decrease in weight during the nesting period. As stated by Pojarkov (1955) hen Partridges lose 1/4 of their weight when brooding, the males body weight decreased less markedly.

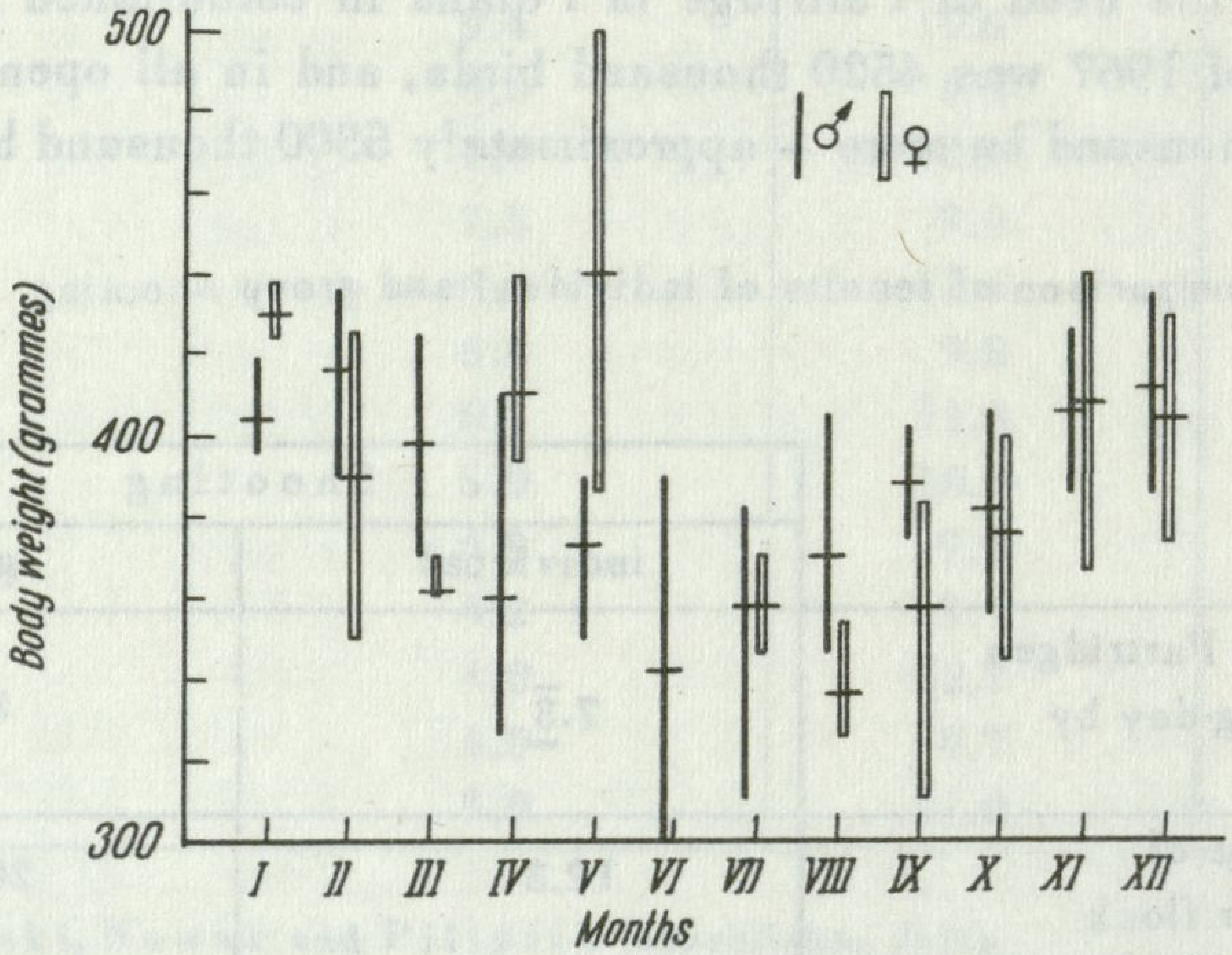

Fig. 2. Seasonal variations in body weight of adult Partridges (average value and range of variations)

Attention is drawn also by Westerskov (1965) to the late autumn and early spring maximum weight of Partridges, and he explains this as partly due to their increased daily ration (up to 50–75 g) of the green parts of plants on which the birds feed in winter and which are present in the crops during weighing. The weight of a full crop at one time of weighing does not, however, exceed 20 g (Oko 1963), which forms at most 5% of body weight. Szwykowska (1969) found that the caloric value of 1 g of fresh body weight of a Partridge (without crop or stomach) is highest during the period November-February (2.2 kcal/g as compared with 1.7 kcal/g during the period from

[2]the high body weight of hen partridges in April and May is connected with egg production.

June-October). Thus the greater weight of Partridges in winter also means their greater value to those making use of them.

The weight of young birds, which during the first part of the open season is below that of adult birds, is even more infavourable. Hell (1965) drew attention to this fact, giving the following average weights for Partridges in Slovakia in August as – adulti – 358 g, juveniles – 297 g. The difference in weight between young and adult birds depends in different years on the date and number of birds in the second brood that is, indirectly on the level of losses in the first brood, but occurs even in good years (Tab. XV). In the table 1966 represents on an average a good breeding season, and 1967 very considerable breeding losses and a higher percentage of chicks from the second brood.

Differences between body weight of immaturi and adulti Partridges during open season

Tab. XV

Year	Sex	Underweight in immaturi (in grammes)						
		3.IX	10.IX	17.IX	24.IX	1.X	8.X	15.X
1966	♂	–	–	–	21.1	31.9	–	-2.4
	♀	–	–	–	18.9	14.5	–	-1.2
1967	♂	66.7	24.7	36.1	24.0	23.0	22.0	23.0
	♀	64.0	33.5	43.9	34.0	28.3	16.0	13.0

Differences in weight between young and adult birds in different samples (voivodships) decrease in successive weeks of shooting. Curve *A* (Fig. 3) illustrates the way in which the weight of young and adult Partridges supplied to a purchasing centre becomes balanced. As the lower weight limits of Partridges accepted for purchase is 280 g, calculation was made of correction to curve *A*, taking into consideration the number and weight of birds rejected as below weight. Such birds formed 19% (29 out of 150 young birds) during the first week of shooting (purchased September 3rd), and 8% (7 out of 90) during the third week of shooting (purchased September 17th). Average weight of Partridges rejected on September 17th was 235 g. If it is assumed than in previous weeks this weight was similar (smaller Partridges are not as a rule shot) then knowing the weight of adult birds it can be calculated that on September 3rd the difference in weight between adult and young cocks was not 66.7 g but 77.5 g, and the difference between young and adult hens not 64.0 g, but 76.7 g, and on September 17th analogically 45.0 g instead of 35.0 g (♂♂)

and 53.0 instead of 45.0 (♀♀). In this way line *B* was obtained, which ilustrates the real difference in the weight of immaturi and adulti Partridges during the open season.

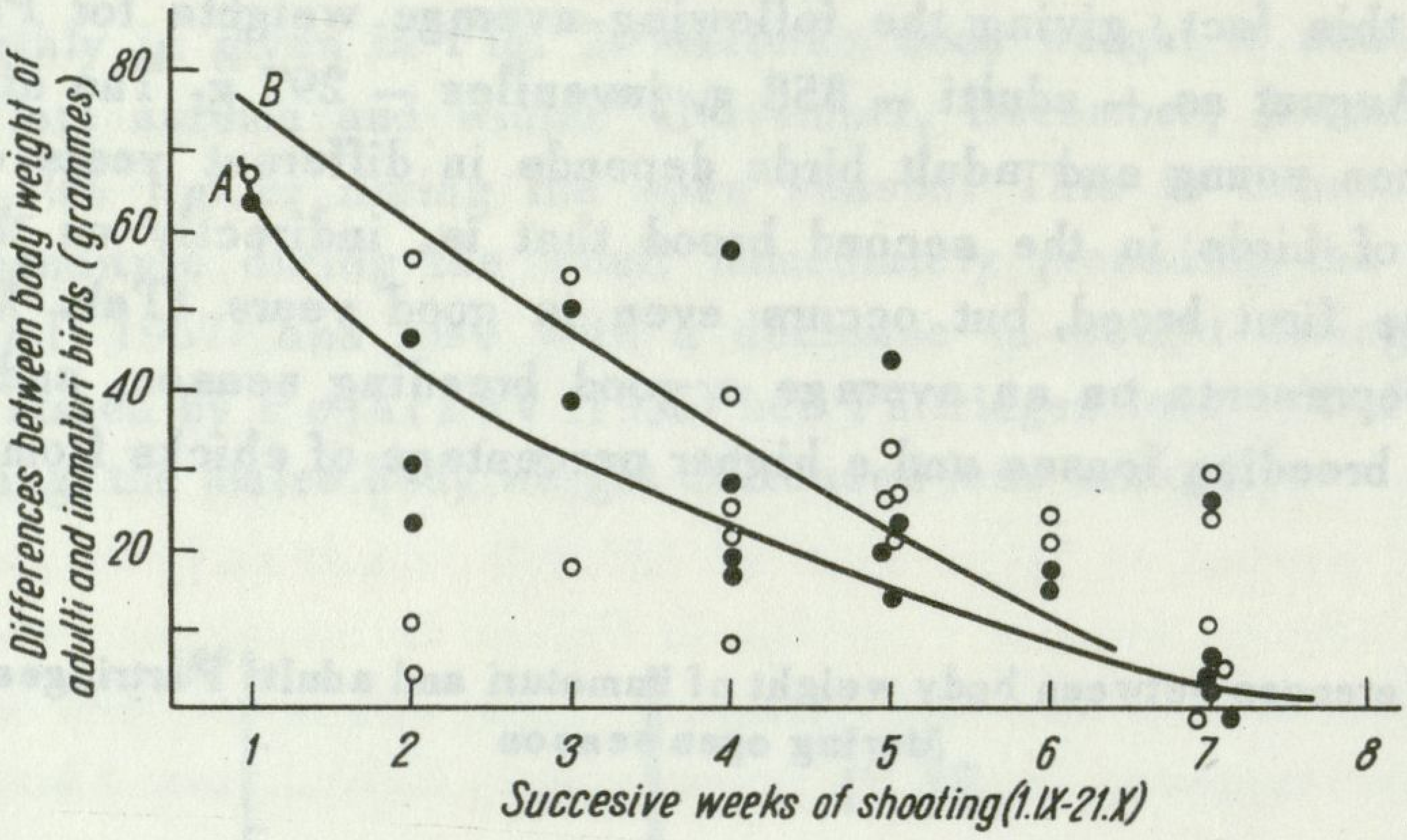

Fig. 3. Difference between body weight of adulti and immaturi Partridges during open season

A — curve of equalization of weight of immaturi and adulti Partridges purchased at purchasing centres, *B* — curve *A* balanced by weight of young birds not suitable for purchase. Open circles represent mean data from different voivodships for males, solid circles for females

4. DISCUSSION

4.1. Genesis of the sex structure of the population

The ratio of hatched Partridge cocks to hens is 142:100 and differs significantly from the ratio 1:1. As the result of postembryonic mortality, which was approximately 70% among Partridges under field conditions (Blank and Ash 1962, Blank, Southwood and Cross 1967, Southwood 1967) and may thus significantly alter the population structure, in summer young birds enter the population with a ratio of 1:1, or still with a slight excess of cocks. As both data from trapping and from shooting reveal a ratio of 1:1 and are based on far larger samples than data from incubation, and also as it is difficult to imagine a mechanism selecting young hens both during shooting and trapping, it must be accepted that the excess of cocks is liquidated during the postembryonic period.

In late autumn and winter (from September to March) the ratio of cocks to hens among the young birds does not change. As shown by data from individual marking of Partridges (Jenkins 1961) the only migrations of Partridges to take place during the year occur between January and April, these birds being outstandingly settled during the remainder of the year. Among 29 migrating individuals Jenkins found 23 young cocks, 4 young hens, 1 adult cock and 1 adult hen. This may be a certain selecting factor as migrants are more exposed to predators. The fact itself of young cocks leaving an area cannot be of significance, as there are equal chances of emigration and immigration. The effect of emigration is particularly strikingly revealed when examining individually marked Partridges, but should not be revealed in studies on sex ratio in the whole population.

In Partridges over 1 year old, that is, already taking part in nesting, a significant excess of cocks was found, averaging 40 cocks per 100 pairs. This excess can only be caused by some factor causing higher mortality among adult hens. The most probable would appear to be increased mortality among hens during the nesting period. This phenomenon is known in ornitological literature but there have been few attempts at estimating its extent (Summers-Smith 1963). If it proved possible to show that at different times of the year mortality among cocks and hens is equal, that is, that the whole excess of cocks should be attributed to nesting mortality among hens, then it would be possible on the basis of the age structure of both sexes to calculate the measure of this selection. For this purpose the ratio of adult cocks and hens to young during the annual cycle was taken as a basis (Tab. XVI). The

Comparison of mortality of adult cocks and hens in autumn and winter

Tab. XVI

Sex	Number of adult individuals/100 young			Mortality of adults/100 young (Sept. 1966 – March 1967)	
	21 Sept.–21 Oct. 1966	January 1967	March 1967	number	percentage
♂♂	23.3*	19.1	14.9	8.4	36.1
♀♀	17.8	11.6	10.6	7.2	40.5

*with correction for selective shooting of cocks.

number of adult cocks and hens per 100 young decreases during the period from autumn to early spring. Losses are similar in both sexes: 36.1% in cocks and 40.5% in hens. The difference is not significant. It must be remembered that the above values can only serve for comparisons of the mortality among the two sexes and to not define the extent of this mortality, as the absolute number of young Partridges decreases during this period. The excess of cocks may therefore arise during the period from April to August, when the most likely cause of selective mortality among hens is the nesting period.

Thus after transition from the immaturi to adulti class the ratio of cocks to hens changes from 100:100 to 140:100. If the number of overlapping generations is known it is possible to calculate the breeding mortality among hens in the first, second etc. breeding season. In fact two generations of hens meet during the breeding season: birds one year and two years old. It is known from the age structure that their ratio is 140:38, that is, out of 100 adult hens 78.7 are one year old and 21.3 two years old. If under field conditions there are 140 cocks for every 100 hens, this is equal to 100 cocks: 71.4 hens, which means that 28.6% of the hens have died. Mortality thus affected 78.7% during one and 21.3% during two breeding seasons. The equation may be put as follows:

$$\frac{78.7}{100} \cdot \frac{x}{100} + \frac{21.3}{100} \cdot \frac{2x}{100} = \frac{28.6}{100}$$

From this x = 23.6%. This is the average mortality among adult hens during the course of one breeding season.

It is now necessary to check if mortality among hens is equal in their first and second nesting season. On the basis of the age structure it is possible to calculate the survival index $u = \frac{l_2}{l_1}$ between the second and third year of life, that is between one-year and two-year age classes for cocks and hens separately. They are:

$$\mu \, ♀♀ = \frac{38}{140} = 0.270 \qquad \mu \, ♂♂ = \frac{98}{170} = 0.576,$$

This shows that 58 out of every 100 one-year old cocks survive to the following year, 42 die, whereas 27 hens survive and 73 die. As mortality is the same in both sexes apart from the nesting season, this difference is due to the higher mortality rate among hens during the nesting season. 73 − 44 = 29 hens out of each 100 one-year old hens die during the next nesting season, and thus mortality among hens in their second nesting season is 29%.

It would be more difficult to calculate mortality among hens during the first nesting season by means of this equation, as it is not known what value to put under l, in view of the considerable fluctuations in the number of young from year to year. An attempt may be made at calculating this in a different way. It is known that in the one-year old group there are 140 ♀♀ per 170 ♂♂, that is 121:100. These birds had exhibited a sex ratio of 1:1 as immaturi the previous winter, that is 100 ♂♂ : 100 ♀♀. It follows from this that 21 hens out of 121, that is 17.4%, must have died as the result of nesting mortality.

It is difficult to estimate whether a difference of this sort in mortality among hens in the first and second nesting season comes within the limits of error, or illustrates the actual state of affairs. If nesting mortality among one--year old hens (that is 78.7%) is 17.4% and older birds (that is 21.3%) is equal to 29%, then their average mortality is 19.5%.

4.2. Selective effect and permissible extent of shooting

One of the important matters meriting discussion is the problem whether the selective effect of shooting on adult cocks, which is of interest to game management, contributes to reducing their excess in the field. As already shown, under Polish conditions shooting removes on an average 12% of Partridges from the population. Young birds can continue to be omitted as they are selected by shooting in the same ratio as they occur under field conditions. Calculation would thus affect adult birds only:

if from a population in which ratio ♂♂:♀♀ is 140:100 we remove 10% in the ratio of 160:100 (since adult Partridges are shot in this ratio) then:

in the area there is	100% = 240 individuals	(140 ♂♂ + 100 ♀♀)
shooting removes	10% = 29 individuals	(18 ♂♂ + 11 ♀♀)
which leaves	90% = 211 individuals	(122 ♂♂ + 89 ♀♀)

The ratio 122:89 does not significantly differ from the ratio 140:100, that is, with the above degree of exploitation, despite the fact that it has a selective effect on adult cocks, there is no significant effect on the excess of cocks in the area[3].

The next problem is the permissible extent of utilization of the population. Theoretically it depends on natural mortality and realized production. As

[3]Up to the present use has been made of data obtained by trapping, as the only data reflecting field relations, but trapping operations take place after shooting and can thus only supply information on what is left after shooting operations. Therefore in order to obtain the true proportions of cocks and hens before shooting a further 12% in the ratio of 160:100 must be added to 816 ♂♂ and 585 ♀♀ (ratio 140:100) that is 103 ♂♂ and 65 ♀♀. We obtain the ratio of 919 ♂♂: 650 ♀♀ (141:100). As this does not significantly differ from the ratio obtained from trapping it can be considered that the inaccuracy occurring is not of any important significance to results.

both these values are known for Partridge populations maximum permissible utilization can be presented by means of an equation, with which population numbers in the nesting season preceding and following utilization will not be subject to change. This equation was given by Andrzejewski and Jezierski (1967) in the study on the hare, *Lepus europaeus* L.

$$p = \frac{b - \frac{1}{2}a\,(1-b)}{b - \frac{1}{2}a\,(1-b) - 1} \cdot 100$$

where p — permissible „crop”, a — realized production from 1 adult hen, b — natural mortality apart from utilization. This equation would be fully suitable for calculating annual utilization of a Partridge population (both species reproduce during the annual cycle) if it were not for the index 1/2 involved in it expressing the number of hens in relation to the total number of individuals. As already shown, in the case of Partridges this ratio differs from the value 1/2. In order to calculate it during the nesting period, since this is the period concerned in the equation, the fact that in the case of birds completing their first year of life the ratio ♂♂ : ♀♀ is 100:100, and in older on an average 140:100, must be taken into consideration. In winter the ratio of young birds (which complete one year of life during the nesting period) to adults is 3.1 (average from Tab. VIII), that is, there are 75% of young birds among those beginning reproduction (sex ratio 100:100) and 25% of older birds (sex ratio 140:100). The average is thus 110:110. It is therefore necessary in the case of Partridges to replace the value 1/2 by 0.48 in the equation for permissible utilization. With a calculated annual mortality of 60%, 10% of which is due to shooting and 50% to natural mortality, and realized production per adult hen varying from 3.5 to 8.9 individuals — the permissible „crop” value is expressed by the curve in Fig. 4. The figure shows that with production greater than 4 young from 1 hen and with natural mortality (apart from shooting) of 50% annually, utilization can take place in 30% of the population (or correspondingly more) without harm to its numbers in the following open season. With higher production 7 or 8 young per hen, shooting when natural mortality remains on the same level may be as much as over 50%.

In view of the fact that on an average shooting in Poland affects only 12% of the head of game in the field this must be considered as very low and exerting only a minimal influence on population numbers. This is confirmed by the fact that despite the higher than average utilization of Partridge populations in the central voivodships of Poland i.e. 22% (Tab. XII), they are among the voivodships with the greatest numbers of these birds. Even higher utilization, 30%, is observed in Holland (Troostwijk 1968). Total mortality there is 80%, and thus natural mortality forms, as in Poland, approximate 59% but realized production is slightly higher (ratio immaturi:adulti in 1964 and 1965 was 3.6 and 2.7) and even so no general decrease in numbers is observed.

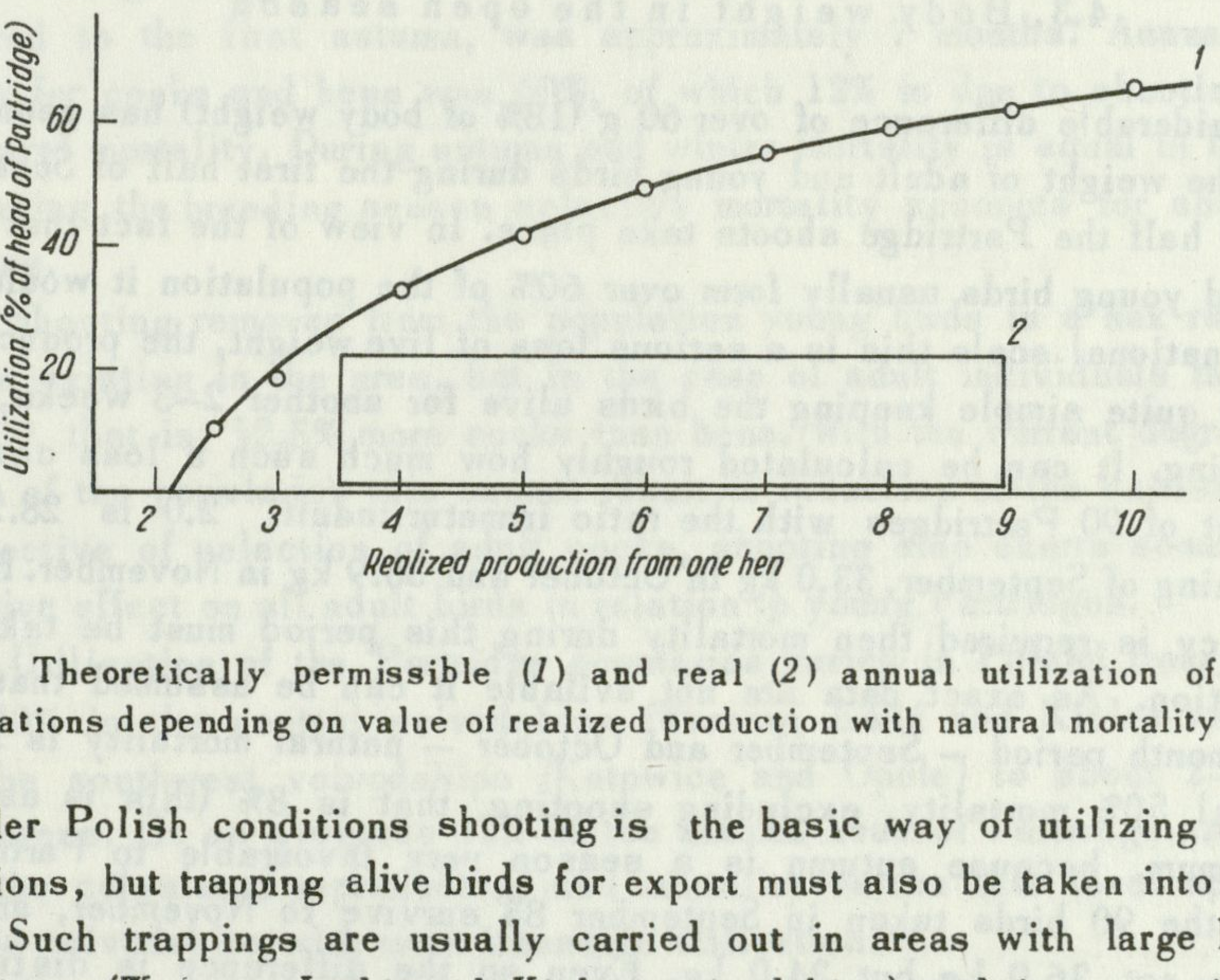

Fig. 4. Theoretically permissible (*1*) and real (*2*) annual utilization of Partridge populations depending on value of realized production with natural mortality of 50%

Under Polish conditions shooting is the basic way of utilizing Partridge populations, but trapping alive birds for export must also be taken into consideration. Such trappings are usually carried out in areas with large Partridge populations (Warsaw, Łódź and Kielce voivodships) and in comparison with shooting their value is not great. According to data published by the Chief Census Bureau (Główny Urząd Statystyczny 1968) the following numbers of Partridges were caught for export from 1965–1968: 15,212, 23,876 and 18,220. As trapping takes place later than shooting it would of course be necessary to take anticipated trapping for export figures into consideration when planning shooting.

It is, however, very difficult to plan the number of Partridges to be shot sufficiently early, as the two indices conditioning permissible „crop", particularly realized production, fluctuate considerably. For instance according to the data for ten years from Burgate Manor (Eley Game Advisory Station 1967) realized production (expressed by the ratio immaturi:adulti) varied from 0.59 to 2.94. This is understandable since the chief factor regulating the numbers of Partridges, the so-called key factor, with relatively very constant value of removals is mortality among chicks (Southwood 1967). There is well-founded evidence to show that realized production of young has decreased in England during the present century by about 2 young for each adult hen due to increased mortality among chicks (Middleton 1935, Blank and Ash 1962, Eley Game Advisory Station 1967, Southwood 1967) and it is this, and not excessive utilization of the population, which accounts for the trend to reduction in numbers of Partridges.

4.3. Body weight in the open season

A considerable difference of over 60 g (18% of body weight) has geen found between the weight of adult and young birds during the first half of September, when over half the Partridge shoots take place. In view of the fact that during this period young birds usually form over 60% of the population it would seem that on a national scale this is a serious loss of live weight, the production of which, by quite simple keeping the birds alive for another 2–3 weeks, would cost nothing. It can be calculated roughly how much such a loss comes to: e.g. weight of 90 Partridges with the ratio immaturi:adulti 2.0 is 28.2 kg at the beginning of September, 33.0 kg in October and 36.9 kg in November. If greater accuracy is required then mortality during this period must be taken into consideration. As exact data are not avilable it can be assumed that during the two month period – September and October – natural mortality is 2/12 of the annual 50% mortality, excluding shooting, that is 8% (this is assuming the maximum, because autumn is a season very favourable to Partridges). Thus of the 90 birds taken in September 83 survive to November, and their weight is not 36.9 kg but 34.0 kg. Even so the difference is distinct and judged on the scale of the hundreds of thousands of Partridges which are shot in Poland every year (Tab. XII) may be of economic importance. For instance in 1967–558 thousand Partridges were shot in Poland (Andrzejewski, Nowak and Pilipiuk 1968) out of which 56.1% were shot during the first half of September. If the 56.1% had been shot in November they would have jointly weighed (taking into consideration natural mortality during this period) 20 thousand kg more than in September.

5. SUMMARY

1. The methods used made it possible to estimate the majority of population indices, such as realized production, mortality, age structure and sex ratio on the basis of utilization operations, and this would appear to be the only way to collect sufficiently abundant material on game animals.

2. The proportion of cocks and hens among Partridges in Poland are 142:100 among hatching chicks, 100:100 among young birds from the first autumn of life until the first breeding season, and on an average 140:100 among all older birds, in which the excess of cocks increases with age.

3. Realized production of young per 1 adult hen fluctuated from 1965–1967 within limits of 5.3 to 8.9, and expressed by the ratio of immaturi : adulti is from 2.0 to 3.7, average 3.1.

4. Average length of life under Polish conditions of Partridges which survived to the first autumn, was approximately 7 months. Annual mortality jointly for cocks and hens was 60%, of which 12% is due to shooting and 48% to natural mortality. During autumn and winter mortality is equal in both sexes, but during the breeding season selective mortality accounts for about 20% of the hens.

5. Shooting removes from the population young birds in a sex ratio similar to that existing in the area, but in the case of adult individuals this ratio is 160:100, that is, 12.5% more cocks than hens. With the current degree of utilization of the population this cannot result in reduction of the excess of cocks. Irrespective of selection of adult cocks, shooting also exerts some degree of selective effect on all adult birds in relation to young Partridges.

6. Utilization of the Partridge population varies in Poland from approximately 20% in the central voivodships (Warsaw, Łódź and Kielce voivodships) and the southwest voivodships (Katowice and Opole) to about 2–5% in the other areas. On an avegarde 12% of the autumn head of Partridge are shooting. With the calculated reproduction and mortality values this level appears low, even in voivodships with most intensive utilization.

7. The total number of Partridges in September 1967 in the whole of Poland was assessed at approximate 5.5 million birds.

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PRZYROST ZREALIZOWANY, ŚMIERTELNOŚĆ I STRUKTURA PŁCIOWA POPULACJI KUROPATW (*PERDIX PERDIX* L.) A JEJ UŻYTKOWANIE ŁOWIECKIE W POLSCE

Streszczenie

Badania nad populacją kuropatw (*Perdix perdix* L.) prowadzono na terenie całego kraju w latach 1965–1968 określając: 1) proporcje płci wylęgających się piskląt, 2) strukturę wiekową i płciową populacji w zimie w oparciu o odłów, 3) strukturę wiekową i płciową kuropatw odstrzeliwanych w okresie polowań (1 IX–21 X), 4) ogólne prawidłowości polowania na kuropatwy w oparciu o ankietę do myśliwych, 5) sezonowe zmiany ciężaru ciała kuropatw ze szczególowym uwzględnieniem okresu polowań.

Parametry populacyjne. Proporcja płci u ptaków wylęgających się wynosi 142 ♂♂ : 100 ♀♀, przy czym nadwyżka samców jest istotna. W jesieni (wiek ok. 2 miesiące) ilość młodych samców i samic wyrównuje się. Znana z praktyki nadwyżka kogutów w populacji kuropatw (ok. 140 ♂♂ : 100 ♀♀) rekrutuje się z osobników starszych, powyżej 1 roku życia i powiększa się z wiekiem. Przyczyną jej jest selektywna śmiertelność samic biorących udział w rozrodzie (o 20% wyższa, niż samców). Poza okresem lęgowym śmiertelność naturalna obu płci jest równa.

Frekwencja kuropatw (obu płci łącznie) w grupach wiekowych co 1 rok badanych we wrześniu wynosi 100, 22, 9. Obliczona stąd średnia długości życia osobników, które dożyły swego pierwszego września wynosi 6,7 miesiąca, a roczna śmiertelność – 60%.

Przyrost zrealizowany wahał się w badanych latach od 2,0 do 3,7 i należy go oceniać jako przeciętny, a nawet dobry na tle innych danych europejskich.

Ciężar ciała dorosłych kuropatw w cyklu rocznym waha się w granicach 30%, maximum osiąga w zimie (XII, I), minimum po rozrodzie, w okresie pierzenia (VII i VIII).

Charakterystyka kuropatw odstrzeliwanych. W okresie polowania na kuropatwy młode są już lotne, ale ciężar ich, szczególnie tych z drugiego lęgu, znacznie (średnio o 20%) odbiega od ciężaru dorosłych.

Polowanie usuwa z populacji ptaki młode zgodnie z proporcją płci w terenie (czyli 1:1), natomiast wśród dorosłych selektywnie samce (160 ♂♂ : 100 ♀♀, czyli o 12,5% samców więcej, niż wynosi ich udział w populacji). Przy obecnym niskim stopniu eksploatacji populacji (ok. 12%) nie ma to istotnego wpływu na zmniejszenie nadwyżki kogutów. Stwierdzono także, że polowanie działa w niewielkim stopniu selektywnie na ptaki dorosłe w ogóle, wymaga to jednak dalszych badań.

Polowanie jako zabieg eksploatacyjny. Na podstawie przeprowadzonej wśród myśliwych ankiety dotyczącej ilości i liczebności napotkanych w czasie polowania stąd

oraz liczby ptaków zastrzelonych, z uwzględnieniem miejsca i czasu trwania polowania, obliczono, że stopień eksploatacji stada waha się od 7–12% na terenach o niskim stanie kuropatw i od 16–20% na terenach o wysokim stanie kuropatw. Przy pomocy wyliczonego wskaźnika opolowania terenu oceniono stopień eksploatacji całej populacji. Wynosi on przeciętnie na terenie całej Polski ok. 12%. Liczba ta określa, ile odstrzeliwuje się w rzeczywistości kuropatw ze stanu jesiennego przy obecnych normach polowania (odstrzał 1/2 przyrostu, czyli ok. 30% populacji jesiennej), oraz pozwala ocenić stan kuropatw w danym regionie na podstawie wyników polowań.

Wynikające z pracy wnioski dla praktyki:

1. Wyliczony stopień eksploatacji populacji kuropatw przy stwierdzonych na naszych terenach wartościach śmiertelności i rozrodu oceniono jako niski nawet w województwach o intensywniejszej eksploatacji, jak kieleckie, łódzkie czy krakowskie (eksploatacja 20–27%) w porównaniu z dopuszczalną eksploatacją obliczoną jako funkcja przyrostu zrealizowanego i śmiertelności naturalnej.

2. Ponieważ ponad 50% polowań na kuropatwy odbywa się w początku sezonu (pierwsze dwa tygodnie września), kiedy ciężar zarówno młodych, jak i dorosłych znajduje się znacznie poniżej maksymalnego, wydaje się celowym przesunięcie maksimum eksploatacji na okres późniejszy o ok. 1 miesiąc. W skali krajowej, przy uwzględnieniu śmiertelności naturalnej w tym okresie, zwiększyłoby to ogólną masę pozyskanej zwierzyny o wielkość rzędu 50 tys. sztuk rocznie.

3. Przy dotychczasowej intensywności odstrzału polowanie nie zmniejsza istotnie nadwyżki kogutów w populacji.

AUTHOR'S ADDRESS:
Dr. Bogumiła Olech,
Instytut Ekologii PAN,
Dziekanów Leśny k. Warszawy
pow. Nowy Dwór Mazowiecki
Poland.