77

BARD

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An Integrated Approach to the Breeding, Nutrition, Reproduction and Management of Geese

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B. TABLE OF CONTENTS

	<u>Page</u>
C. ABSTRACT	1
D. OBJECTIVES OF ORIGINAL RESEARCH PROPOSAL	2
E. BODY OF THE REPORT:	4
E1. Breeding Geese for Egg Production, Fertility, Liver Weight and Liver Quality (Israel)	5
1. Evaluation of breeds	5
2. Differences between sexes in liver weight and body weight	7
3. Correlation between liver weight and body weight	8
4. Heritability estimates	9
5. Egg production data and correlation between part- and full-time records of egg production	10
6. Correlation between traits	13
7. Selected population	15
8. Genetic gains of egg number and liver weight	15
9. Genetic-economic evaluation of traits in a goose broiler enterprise	16
10. Genetic-economic evaluation of traits in a goose liver enterprise	37
E2. The Nutrition of Geese During Different Stages of age and Production (Israel)	38
1. The growing period	38
1.1 Protein, essential amino acids and glycine requirements of the growing gosling	38
1.2 The effect of dietary energy and fiber concentration on body weight gain, food intake and utilization, organs weight and fatty liver weight after cramming	39

1.3	Feeding mash or pellets to growing goslings from 4 to 10 weeks of age	44
2.	Qualitative and quantitative food restriction prior to cramming	45
2.1	Qualitative restriction of food intake	45
2.2	Quantitative restriction of food intake	47
3.	The nutrition of the laying goose	48
3.1	Protein and energy consumption of laying geese having access to separated protein rich or energy rich diets	48
3.2	The effect of feeding simultaneously a layer and a grower diet to laying geese	52
4.	Nutrition during cramming	55
4.1	The effect of adding various fats to a force-fed diet on goose fatty liver	55
E3.	The Effect of Photoperiodism, and Housing on Egg Production and Fertility (Israel)	58
1.	Development of practical techniques for semen collection from ganders and for insemination of laying geese	58
2.	Housing laying geese in cages	61
3.	Egg production and fertility in geese housed in individual pens	62
4.	Photostimulation and regulation of egg in geese	64
4.1	Supplementation of artificial light from various sources at two intensity levels	64
4.2	Shifting egg production of geese to late summer and fall	68
4.3	Regulation of egg production in geese with light restriction at 6, 8, 10 weeks vs. force molt	70

4.4	The effect of daylight on the duration of the egg production period in geese	81
E4.	Nutrition and Photoperiodism During Different Stages of Age and Production (U.S.A.)	87
	Introduction (U.S.A.)	87
	Material and Methods	90
	Results:	91
	Year 1 - Nutrition and lighting for the growing period	91
	Nutrition and lighting for the prebreeders	94
	Year 2 - Nutrition and lighting for breeders	95
	Year 3 - Nutrition and lighting for breeders	97
	Nutrition and lighting for recycled breeders	99
	Discussion (U.S.A.)	101
	Prolactin and luteinizing hormone levels in Embden geese during photoperiodically-induced reproductive cycle	106
	Summary and Conclusion (U.S.A.)	110
F.	DESCRIPTION OF COOPERATION	127
G.	EVALUATION OF THE RESEARCH ACHIEVEMENTS WITH RESPECT TO THE ORIGINAL RESEARCH PROPOSAL	129
H.	BENEFIT TO AGRICULTURE	133
I.	LIST OF PUBLICATIONS	135

C. ABSTRACT

An attempt was made to initiate fundamental studies in all aspects of a modern goose industry. The achievements of this project are:

Breeding. 1. Evaluation of different breeds/strains, or their crosses, and establishing suitable male and female lines. 2. Estimation of heritability values and correlation coefficients for and between all traits involved. 3. Establishing genetic-economic values for all traits involved, either for a goose broiler, or a goose liver enterprise. 4. In four generations of selection the genetic gains increased production by 13 eggs and by 145 g of crammed liver weight per goose (approx. 25%).

Nutrition. 1. Establishment of protein and energy requirements for the growing, precramming, prelaying and laying periods. 2. Determination of essential amino acids requirements for the growing goslings. 3. The use of ground straw in precramming diet and addition of fat to the forced-fed diet, to improve liver weights. 4. Qualitative and quantitative food restriction during the precramming and prelaying periods resulted in saving of energy and protein. Split diets in breeders improved food utilization and production.

Management. 1. A short and constant daylight regime (10-13 hours) greatly increased egg production and luteinizing hormone level, compared to a long or increased daylight regime (16-17 hours). 2. Light restrictions and forced molt made possible the shifting of the seasonal egg production to late summer. 3. Fluorescent light and 20 lux intensity were advantageous over incandescent light and 50 lux intensity. 4. Practical techniques were developed for semen collection. 5. Housing laying geese in individual floor pens nearly doubled egg production compared to those kept in flocks.

D. OBJECTIVES OF ORIGINAL RESEARCH PROPOSAL

The original research objectives (see proposal August, 1981, p. 5) were as follows:

1. To establish an efficient goose breeding program (including progeny testing) for improving breeds and testing their crosses.
2. To estimate genetic and phenotypic parameters for the above traits.
3. To define amino acid and energy requirements of growing goslings and laying geese.
4. To determine nutritional requirements for optimal size combined with maximal quality in fattened livers.
5. To develop methods of light restriction and decreasing lighting regimes for year-round egg production.
6. To study the effect of light intensity and light spectra on egg production and fertility.
7. To develop a suitable cage for breeding geese.
8. To develop techniques of artificial insemination for use with 2.4.a and for reducing the number of males required in pen breeding.

All these original objectives were investigated and results are described fully in the following pages. Moreover, as the research has progressed additional objectives were studied:

1. Genetic-economic evaluation of traits in either goose broiler, or goose liver enterprise (Israel).

2. The effect of daylight on the duration of the egg production period in geese kept in conventional open houses (Israel).
3. Response to photoperiod regimes during the growing period and hormone levels at different daylight regimes during various stages of egg production (U.S.A.).

E. BODY OF THE REPORT

E1. BREEDING GEESE FOR EGG PRODUCTION, FERTILITY, LIVER WEIGHT AND LIVER QUALITY (ISRAEL)

1. Evaluation of breeds

In order to start with the best breeds or lines available, tests were conducted. Each breed or line was tested annually for chick production by a flock of 50-200 females in four repetitions during 8 years and for progenies' performance by approximately 100 of each sex in six trials during the years 1982-83.

The first year of BARD project was to summarize and fill in tests for the evaluation of breeds especially for the cross between lines. Results are presented in Table 1.

Table 1

Production of several breeds during 1976-1983* and progeny performance in 1982-1983** in Acco

Traits	Breeds	Landaise (L)	Local White(W)	Local Grey(G)	GxW	Rhenish	LxG
*Hen day egg number (Sept.-May)		43.1 ^c	52.7 ^a	48.9 ^b		50.3 ^{ab}	
*Fertility (%) (Sept.-May)		77.9	79.2	77.3	79.6	79.2	77.9
*Hatch of fertile (%) (Sept.-May)		85.3	85.4	85.3	85.5	83.1	85.4
**Liver weight (LW) (g)		620 ^a	546 ^b	690 ^a	643 ^a	490 ^b	640 ^a
**Live body weight (g) before cramming (BWB)		4410 ^a	4009 ^c	4117 ^c	4094 ^c	4240 ^b	4290 ^b
**Live body weight (g) after cramming (BWA)		8640 ^a	7616 ^d	7662 ^d	7741 ^d	7880 ^c	8260 ^b
**Liver weight as percent of BWB		14.1 ^c	13.6 ^c	16.8 ^a	15.7 ^b	11.6 ^d	14.9 ^c
**Liver weight as percent of BWA		7.2 ^c	7.2 ^c	9.0 ^a	8.3 ^b	6.2 ^d	7.8 ^b

Values with different superscript letters were significantly different (p<0.05).

Results (Table 1) indicate that the two local breeds or lines, "White" (W) and "Grey" (G), seem to fit best local demands. As a consequence of this work a multiplier farm has been established this year to serve the Israeli industry. Where, the W line serves as the female line, because of higher chick production, and the G line as the male line, because of greater liver weight. The GxW cross has shown a substantial improvement in liver weight, as compared with the W line, but still somewhat less than the G line (Table 1).

2. Differences between sexes in liver weight and body weight

In order to learn the importance of sexing in liver production, 6 trials were carried out, which involved about 200 goslings of each sex in each trial and line. Results are summarised in Table 2.

Table 2

Differences between sexes within lines and their cross

Traits	"Grey" line			"White" line			Line cross		
	Male	Female	M+F	Male	Female	M+F	Male	Female	M+F
Live body weight before cramming (g)	4307 ^a	3927 ^b	4117	4220 ^a	3798 ^b	4009	4302 ^a	3886 ^b	4094
Live body weight after cramming (g)	7886 ^a	7458 ^b	7662	7760 ^a	7471 ^b	7616	7951 ^a	7531 ^b	7741
Liver weight (g)	702	677	690	525	566	546	640	646	643
Liver weight as percentage of body weight before cramming	16.3 ^b	17.2 ^a	16.8	12.4 ^d	14.9 ^c	13.6	14.9 ^c	16.6 ^{ab}	15.7
Liver weight as percentage of body weight after cramming	8.9 ^a	9.1 ^a	9.0	6.8 ^d	7.6 ^c	7.2	8.0 ^b	8.6 ^a	8.3

Values with different superscript letters were significantly different ($p > 0.05$)

Accordingly (Table 2), it seems that there are significant differences between body weights of males and females which affect liver weight when expressed as percentage of body weight, but in absolute terms there were no significant differences between the liver weights of the two sexes. Therefore, there is no need of sexing progenies for the testing of liver weights, and thus there is no loss in selection pressure.

3. Correlation between liver weight and body weight

Progeny test for liver weight is very expensive, therefore it appeared important to study the correlation between liver weight and live body weight. If a high correlation would be found, then mass selection could be applied on the live birds on the basis of body weight in order to select for increased liver weight.

Measurements were taken in 6 trials of about 100 goslings of each sex and line and correlations were calculated then summarized (Table 3).

Table 3

Correlation coefficients between body weights and fattened liver weights of the "Grey" and "White" lines

Correlation	"Grey" line		"White" line	
	Male	Female	Male	Female
Live body weight before cramming x liver weight	0.13	0.11	0.18	0.15
Live body weight after cramming x liver weight	0.29	0.34	0.22	0.12
Live body weight gain during cramming x liver weight	0.23	0.33	0.05	-0.03

Results obtained indicate that the correlation coefficients between liver weights and live body weights were low for both lines and sexes (Table 3). Therefore, live body weight cannot be an aid in breeding for liver weight.

4. Heritability estimates

Heritability (h^2) estimates were evaluated by two methods: analysis of variance (ANOVA) of half-sibs and offspring-parent regression. In each line were 20-30 sire families, 3 dams and 6-12 progenies per sire in the first two years and about 80 sire families in the 3rd year. Results are summarized in Table 4.

Table 4

Average heritability estimates (h^2) of goose traits of the "Grey" line from 1982 to 1985.

	ANOVA	Offspring-parent regression		
	half ₂ sibs h^2_s	h^2_s	h^2_d	h^2_{s+d}
Live body weight before cramming	0.44	0.43	0.46	0.44
Live body weight after cramming	0.27	0.32	0.38	0.37
Liver weight	0.43	0.39	0.37	0.42
Liver fat	0.29	0.30	0.29	0.30
Number of cramming days	0.25	0.26	0.28	0.27
Abdominal fat	0.48			
Egg number	0.35		0.33	

Table 5

Average heritability estimates (h^2) of goose traits of the "White" line from 1982 to 1985.

	ANOVA	Offspring-parent regression		
	half ₂ sibs h^2_s	h^2_s	h^2_d	h^2_{s+d}
Live body weight before cramming	0.46	0.44	0.46	0.45
Live body weight after cramming	0.35	0.34	0.38	0.37
Liver weight	0.42	0.49	0.30	0.44
Liver fat	0.35	0.32	0.34	0.33
Number of cramming days	0.29	0.29	0.32	0.31
Abdominal fat	0.50			
Egg number	0.39		0.37	

Results of Tables 4 & 5 suggest that heritability estimates for abdominal fat, body weight (before cramming), liver weight and even egg number are relatively high.

5. Egg production data and correlation between part- and full-time records of egg production

Recording of the first year egg production of geese was carried out in 170 single pens for the "Grey" and "White" lines, and the results are presented in Tables 6,7,8.

Table 6

First year egg production datas of geese of the "Grey" (G) and "White" (W) lines

Up to end of month	Mean egg No.		Standard Deviation		Coefficient of Variation (%)	
	<u>G</u>	<u>W</u>	<u>G</u>	<u>W</u>	<u>G</u>	<u>W</u>
September	0.03	3.28	0.18	3.82	600.00	116.46
October	7.43	9.56	4.85	8.86	65.28	92.67
November	15.23	18.15	9.91	12.76	65.07	70.30
December	21.93	26.81	15.58	16.95	71.04	62.22
January	28.93	37.13	21.36	19.68	73.83	53.00
February	39.20	49.35	24.38	22.15	62.19	44.88
March	52.23	63.33	26.89	22.92	51.58	81.29

Table 7

Correlation coefficients between part- and full-time records of egg production of first year geese of the "Grey" line

<u>Up to end of month</u>						
February	0.98					
January	0.96	0.99				
December	0.93	0.96	0.98			
November	0.87	0.90	0.94	0.97		
October	0.61	0.64	0.71	0.76	0.85	
September	-0.29	-0.22	-0.24	-0.24	-0.25	-0.21
	MARCH	FEB.	JAN.	DEC.	NOV.	OCT.

Table 8.

Correlation coefficients between part- and full-time records of egg production of first year geese of the "White" line.

Up to end
of month

February	0.94					
January	0.93	0.93				
December	0.86	0.88	0.96			
November	0.74	0.78	0.83	0.94		
October	0.52	0.57	0.59	0.73	0.89	
September	0.36	0.41	0.43	0.56	0.73	0.90
	MARCH	FEB	JAN	DEC	NOV	OCT

Table 6 shows that the coefficient of variation of geese egg production is extremely high and that there exists an 11-eggs advantage of the "White" over the "Grey" line.

Tables 7 and 8 indicate that the correlation between egg production up to end of December with total egg production (end of March) is very high (0.93 and 0.86). However, it seems from Table 7 that higher producers at the beginning of lay in September (earlier sexual maturity) might have lower production on the whole (negative correlation).

Therefore, sexual maturity should be treated as a separate trait from total egg production or persistency, and this method may improve the correlation of first year egg number with residual years production.

Moreover, a separate test has shown that the selection of 30% of the best layers, based on 3-month egg records, may be sufficient to identify 96% of the

best overall producers for the first year. However, the correlation between the first year egg production (when sexual maturity is included) and other years production is relatively low (Merritt and Lemay, 1963; Bielinski, Rosinski and Bielinska, 1984).

A study carried out on the data of egg production of geese during ten years (Rodewyk, 1950) shows that selecting the best 20% layers on the basis of first-year egg number, results in a significant advantage over the lowest 20% producers when based on the average production for ten years.

6. Correlation between traits

Correlation coefficients between traits are important in developing a breeding policy, constructing selection indices and expected genetic gains.

Average of 7 data sets, of 100-200 geese of 170 sire families, were analysed and results are presented in Table 9.

Table 9.

Phenotypic (rp) and genetic (rg) correlation coefficients between goose traits of the "Grey" and "White" lines

Trait	Body weight before cramming		Body weight after cramming		Fertility		Liver weight	
	<u>rp</u>	<u>rg</u>	<u>rp</u>	<u>rg</u>	<u>rp</u>	<u>rg</u>	<u>rp</u>	<u>rg</u>
<u>"Grey" line</u>								
Fertility	-0.17	-0.12	-	-	-	-	-	-
Liver weight	0.12	0.16	0.32	0.24	0.03	-0.05	-	-
Cramming days	0.09	0.12	0.06	0.08	0.01	0.002	0.06	0.09
Egg no.	-0.08	-0.10	-	-	0.08	0.12	0.07	-0.08
<u>"White" line</u>								
Fertility	-0.22	-0.18	-	-	-	-	-	-
Liver weight	0.16	0.18	0.17	0.20	0.11	-0.02	-	-
Cramming days	0.15	0.11	0.16	0.14	0.01	0.03	-	-
Egg no.	0.09	-0.02	0.06	0.15	-0.05	-0.09	-	-

From Table 9 it can be seen that correlation coefficients between traits are still relatively low, and therefore selection on one trait is not at the expense of any other.

7. Selected Population

After four generations of selection, about 40 families of each line were selected. The performance of each selected goose was at least: 52 eggs, 78% fertility and 800 g liver weight. Selection was based on individual and family selection as well as progeny testing. Selection intensity was of about 30% for egg production or fertility, and 20% for liver weight (Shalev, 1984).

8. Genetic gains of egg number and liver weight

Field tests were carried out on selected lines performance versus control lines. About 200 dams per line were tested for egg production and 150 progenies were tested in each line for liver weight.

Table 10.

Genetic gains for goose egg and liver production based on selection of four generations

	<u>Egg number</u>	<u>Liver weight (g)</u>
Selected lines	59	728
Control lines	46	583
Difference	13	145

From Table 10 it seems that on the average the annual genetic gains were about 3 eggs and 36 g liver weight.

Genetic gains obtained for egg number were higher than expected (Merritt, 1962; Shalev, 1984), and genetic gains for liver weight were similar to the expected ($\Delta G = \frac{h^2}{2} \cdot i \cdot s = \frac{0.4}{2} \cdot \frac{1.4}{2} \cdot 120 = 33.6 \text{ g}$).

9. Genetic-economic evaluation of traits in a goose broiler enterprise

The following paper, submitted to Poultry Science and based on this project, evaluates all traits involved in breeding for goose meat under Israeli and U.S.A. conditions.

1 GENETIC-ECONOMIC EVALUATION OF TRAITS IN A GOOSE BROILER
2 ENTERPRISE: THE RELATIVE GENETIC-ECONOMIC VALUES.

3
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9
10 (Submitted for publication August 8, 1985)
11

12 ABSTRACT

13 1. Selection for growth rate (assuming annual genetic gain
14 of 4.5%) accounts for about 30%-35% of the annual potential
15 economic saving in the production costs of an integrated
16 goose broiler enterprise. Selection for egg number
17 (assuming an annual genetic gain of 1.3%) accounts for about
18 22%-28%. Selection for food utilization and eviscerated
19 yield account for about 19%-23% and 9%, respectively.
20 Selection for fertility/hatchability and reduced mortality
21 account for less than 3% each.

22 2. As egg production of the dams increases, the relative
23 economic value of the performance of the goose broilers
24 (such as growth rate) will increase, while the advantage of
25 genetic improvement in egg production will decrease.

26 3. In grain export countries (where concentrated food is
27 relatively cheap), the relative economic importance of

1 growth rate is reduced by about 5% and that for egg number
2 is similarly increased. A similar effect is expected where
3 the ability of geese to graze on pasture is extensively
4 used.

5 4. Under the assumption of moderate values for annual
6 genetic expected gains of the different traits, the common
7 practice of keeping goose breeders for about 5 years should
8 be seriously questioned, especially as far as the ganders
9 are concerned, since the generation interval may increase
10 beyond genetic economic annual value.

11

12 Key words: GOOSE GENETIC-ECONOMIC VALUES

13 Running head line: GOOSE BROILER RELATIVE GENETIC-ECONOMIC
14 VALUES

15 INTRODUCTION

16 Profit equations were derived per broiler unit (Henry, 1966;
17 Moav and Moav, 1966; Moav, 1973), and savings in production
18 costs were derived in a broiler enterprise (Shalev and
19 Pasternak, 1983) but no such research has been published in
20 geese, to the best of our knowledge. There are two main
21 different targets in raising geese, liver and broiler
22 production. The present paper deals with the relative
23 genetic-economic values of all traits affecting the
24 profitability of a goose broiler enterprise, which in turn
25 affects the breeding policy. Such traits are growth rate,
26 food utilization and fat content (as independent traits),
27 egg production, feather weight, fertility, hatchability and

1 mortality.

2 The basic approach here is the saving in production costs
3 rather than profit per goose unit (kg) through improvements
4 in each of the traits involved in the integrated goose
5 broiler enterprise.

6 7 MATERIALS AND METHODS

8 The economic estimations are based on a fully integrated
9 goose broiler enterprise. It is assumed that improvement in
10 traits will only decrease production costs but not alter
11 production scale of meat or hatching eggs and fixed body
12 weight at marketing. Any improvement of geese hen housed egg
13 production will therefore reduce the number of birds needed
14 to produce a fixed number of goslings and consequently
15 reduce gosling production cost. Any improvement in growth
16 rate will shorten the growth period and reduce the rearing
17 cost (food, labour, depreciation, medication and mortality)
18 to a fixed body weight.

19 In the same way other traits (hatchability, mortality, food
20 utilisation and fat) were economically evaluated.

21 The general model for the estimation of production costs per
22 unit of market live weight is based on the same procedure
23 proposed by Shalev and Pasternak (1983).

24 Data for levels of production of all traits and costs
25 involved were obtained from official bulletins published in
26 Israel (Akko Goose Breeding Research Farm 1964-1981; Israel
27 Egg & Poultry Board reports, 1984), U.K. (ADAS, 1981),

1 Canadal Ontario Ministry of Agriculture and Food, 1978),
 2 U.S.A. (Cooperative Extension Service 1979), and also from a
 3 U.S.A-Israel Agric.& Dev.(BARD) Fund goose project reports
 4 (Shalev et al. 1982-1985). The values are in United States
 5 dollars (\$) and cents (c).

6 RESULTS

7 GROWTH RATE

8 Calculations based on a method proposed by Pasternak and
 9 Shalev (1983) showed that a 70g increase in the mean weight
 10 of male and female geese at 8 weeks of age ,will reduce the
 11 rearing period to a fixed live body weight by one day; the
 12 main saving achieved by marketing a goose broiler one day
 13 earlier is a reduction in food consumption of about 155g for
 14 the average of females and males (Table 1). In the
 15 construction of the equation of Pasternak and Shalev (1983),
 16 two equations for broilers were used: Gompertz equation
 17 (1825) and Hurwitz equation (1978). The Gompertz equation
 18 (1825) was found to fit successfully the goose growth rate
 19 data.

20 Parameters k and l were estimated according to Israeli and
 21 U.S.A. data (see Table 1), and Hurwitz's (1980) maintenance
 22 curves for turkeys were modified to geese. Food costs, as
 23 well as other costs of one additional day of goose
 24 maintenance, are presented in Table 2 at two food price
 25 levels - 26 c (Israel) and 15.7 c (U.S.A.) per kg.

26 The saving of 155 g in food consumption (average of females
 27 and males) accounts for 84.4% - 88.4% (Israel vs. U.S.A.

1 food prices, respectively) of one day's costs at marketing
2 age.

3 The other approximate savings in production costs are:
4 mortality 5.5%-6.3%, labour 1.5%-2.5%, depreciation
5 2.0%-3.1% and all the rest 2.6%. The total saving in costs
6 for a one day reduction in the growth period at marketing
7 age was estimated to be 4.55 c (Israel) and 2.88 c (U.S.A.)
8 for the average of males and females (Table 2).

10 HATCHING EGGS, FERTILITY/HATCHABILITY

11 The production cost of hatching egg was evaluated by
12 dividing the cost of raising a goose hen from the age of one
13 day until the end of the laying period (food, depreciation,
14 medication, labour, etc. minus income from meat, table eggs
15 and manure) by the number of hatching eggs. According to
16 the data available (Israel Egg & Poultry Board, 1984) the
17 estimated cost of a laying goose is \$44.0, or \$1.10 per
18 hatching egg (40 hatching eggs), or \$1.39 per fertile egg
19 (31.7 fertile eggs).

20 It was assumed that the equation of Bornstein et al. (1979)
21 fits also goose hens; accordingly, for each increase of one
22 hatching egg, there is an increment of 173.8g in food intake.
23 Deviations from the 40 hatching egg level for food
24 consumption are presented in Table 3.

25 An increase in fertility and hatchability will reduce the
26 number of goose hens and chick cost. It was assumed (Shalev
27 unpublished data) that for a decrease in annual hatching egg

1 production of 10 eggs ,there is a decrease of 1% in
2 fertility and hatchability (mainly due to negative genetic
3 correlation between selection for body weight vs. egg
4 production and fertility). The value of an additional 1% of
5 fertility or hatchability per goose broiler at various
6 levels of production is given in Table 3.

7 As egg production increased, hatching egg cost decreased
8 from 215.9 c for 20 hatching eggs to 39.4 c for 120 eggs
9 (Table 3). However, the value of an additional hatching egg
10 per goose is decreased from 17.441 c to 0.467 c and the
11 value of additional 1% fertility or hatchability per goose
12 decreased from 5.217 c to 0.737 c for the range of 20 to
13 120 hatching eggs per laying goose.

14

15 FOOD UTILIZATION AND BODY FAT

16 In addition to the correlated response between selection for
17 body weight gain and food consumption which is discussed
18 above, there are indications in the literature on broilers
19 and turkeys (Gilliat, 1983; Leclercq et al. ,1980; Pym and
20 Farrell, 1977; Pym and James, 1979; Pym and Nicholls, 1979;
21 Whitehead and Griffin, 1984,) that food utilization and body
22 fat can be selected for directly, with additional
23 improvement in food utilization. Moreover, selection for
24 improved food utilization reduces fat and vice versa.
25 In ducks (Pingel et al. 1984), selection for high and low
26 feed conversion was carried out for four generations. The
27 results indicate an improvement in food conversion of 15% in

4 generations due mainly to a reduction in body fat from 20.5% to 17.6%, while body weight of the low-fat selected line was not reduced. In geese at 7 weeks of age, fat represents about 18.9% (extracted) of the eviscerated weight (Nitsan Zafrira et al., 1981). Moreover, preliminary results in geese suggest genetic variation in abdominal fat (Shalev unpublished results). Therefore, an annual improvement of about 3% in food utilization due to a reduction of about 0.7% in body fat, is assumed, with a possible improvement of 0.3% in eviscerated yield. The economic values of these traits were computed mainly as savings in food consumption costs, where carcass grading is included. Food saving per 1% reduction in food utilization was 2.65 c per goose broiler (e.g. $4.159 \text{ kg} \times 2.45 \text{ food:gain ratio} \times 26 \text{ c per kg food} \times 1\%$). (Speers and Hamre, 1978; Shalev et al. BARD report, 1984; Israel Egg & Poultry Board, 1984).

MORTALITY

The economic loss due to mortality in goose broilers was evaluated by assuming that an increase in mortality (due to genetic susceptibility) would increase the number of dams in order to obtain a target number of goose broilers, and would include food consumed before the birds died and expenses for medication. One percent mortality was equivalent to 2.73 c per average male and female (Israel Egg & Poultry Board, 1984).

Parent stock mortality is of much less economic importance

1 than the mortality of their progeny , since in an integrated
2 goose broiler enterprise the loss due to parent mortality is
3 divided by the number of goose broilers per dam or sire.

5 FEATHERS

6 The average feather weight of a 4 kg goose was found to be
7 about 95 g (Zobolotnikova et al. 1984; Bogre et al. 1984).
8 At a price of \$6.4 per kg of feathers and down (Israel Egg &
9 Poultry Board, 1984), an additional 1% in feather yield
10 would increase income by 0.61 c per goose.

12 RELATIVE ECONOMIC VALUE OF ALL TRAITS

13 These economic values are summarised in Table 4. At 40
14 hatching eggs per goose hen-housed, the economic value of a
15 genetic improvement of 10 hatching eggs is equal to a
16 genetic improvement of 17.2% in hatchability, or 15.8%
17 reduction in goose broiler mortality, or 16.2% in food
18 utilization, or 4.2% eviscerated yield, 9.5 days earlier
19 marketing weight, or 664 g in live body weight. As level of
20 production increases, the economic importance of growth rate
21 and food utilization increases, whereas the economic values
22 of reproduction traits decrease (Table 4).

23 GENETIC GAINS EXPECTED ANNUALLY

24 In order to obtain the genetic economic values of each
25 trait, the economic values and the genetic gains expected
26 annually have to be considered together. The genetic gains
27 expected annually for the various traits are based on

1 literature (Merritt, 1962) and on results from a U.S.A-
 2 Israel Agric. Res. & Devel. (BARD) Fund goose project
 3 (Shalev et al. 1982-1985). Annual expected genetic gains
 4 for the different traits were economically evaluated for a
 5 5,000 tons/year goose broiler enterprise at two food price
 6 levels (Israel and U.S.A.); results are presented in Table
 7 5. Accordingly, food utilization together with changes in
 8 fat content and eviscerated yield comprise 28.9%-32.2%
 9 (Israel vs. U.S.A. food prices, respectively) of the
 10 economic gains, as compared with 30.3%-35.3% for growth
 11 rate, or 22.8%-28.4% for egg production and 6.5%-8.8% for
 12 feather weight. Selection for fertility and hatchability
 13 or against goose broiler mortality are of little value
 14 (1%-3%) based on a range of standard results.
 15 Cheaper food price (15.7 c/kg - U.S.A.) may decrease the
 16 relative economic value of growth rate from 35.3% to 30.3%
 17 and increase the egg production value from 22.8% to 28.4%
 18 (Table 5).

19 DISCUSSION

20 The genetic-economic evaluation of traits indicate that the
 21 major traits for selection in the goose broiler enterprise
 22 are: growth rate, egg production and food utilization
 23 together with reducing body fat content and increasing
 24 eviscerated yield. Those traits are of about similar
 25 relative importance. Differences in food prices between
 26 grain export (U.S.A.) and import (Israel) countries are
 27 about 40% (15.7 c/kg to 26 c/kg). The use of the cheaper

1 food (U.S.A.) can reduce the relative economic value of
2 growth rate by about 5% and increase the value of egg
3 production likewise (Table 6). The reason being that for
4 growth rate food comprises 84%-88% in saving growth days
5 (Table 2), whereas for egg production food accounts for only
6 55% of all costs.

7 The ability of geese to graze on pasture may reduce
8 concentrated food consumption by about 35% (ADAS, 1981).
9 Therefore, a similar shift in the relative economic values
10 for growth rate and egg production can be expected.

11 The common practice is to keep goose breeder hens and
12 ganders for about 5 years period. In each of these year about
13 6 months are for laying and the other 6 for holding. In
14 contrast, if males are replaced every term of 15 months, that
15 is to say 9 months of growing and 6 working months. At the
16 level of 40 hatching eggs, or about 26 goose broilers per
17 dam (Table 3), each sire (per 3 dams) is responsible for
18 half of the genetic potential of 78 goose broilers. This
19 additional annual genetic improvement due to replacing new
20 sires each term (of 15 months) is worth a value of \$8.85
21 annually per sire in the saving of production costs for
22 growth rate, food utilization and eviscerated yield (Table
23 5). The additional costs of replacing a male every two
24 years seems to be obviously less than the improvement
25 value. As production goes up, the profitability of such
26 replacement will increase. Therefore, the optimum
27 replacement policy of female and male breeders should be

1 given further consideration in order to avoid economic loss
2 due to prolonged generation intervals.

3 As the number of hatching eggs per dam increases (through
4 genetics or management), the relative economic value of
5 changes in growth rate, food utilization and body fat
6 increases, whereas the contrary is true for the value of
7 selection for egg production (Tables 3, 4, 5). This is due
8 to the fact that genetic improvement applied to fecundity
9 can reduce the dam's production costs, whereas genetic
10 improvement in the growth rate and food utilization of goose
11 broilers is multiplied by all the offspring of each dam;
12 hence, as the number of offspring per hen increases, the
13 advantages of the traits of the progeny increase.

14 It is important to mention that, due to fluctuation in
15 heritability estimates of traits, the relative economic value
16 of these traits may vary. However, these variations of
17 expected differences, may have a limited influence on the
18 relative importance of traits. Nor will the relative
19 economic values of traits be affected by inflation, since it
20 will affect costs of all traits similarly.

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TABLE 1

Estimation of food saving due to a reduction of one day
in slaughter age of geese

Parameter	Female	Male	Average
k value	0.0554	0.0552	0.0553
l values	0.2109	0.2202	
* Days to fixed weight	55.1	55.3	55.2
** Food consumption (g)	9,654	10,829	10,242
Food saved per day of reduction in slaughter age (g)	148.91	160.83	154.87

* The fixed final weights for males and females were 4,480 g and 3,837 g respectively.

** The assumed dietary ME was 12.058 kJ/g.

TABLE 2

Estimated costs of keeping goose broiler for one more day
at slaughter age

	At 15.7c per kg food(U.S.A)		At 26.0c per kg food(ISAEL)	
	cents per goose	percent	cents per goose	percent
* Food cost(155g)	2.43	84.4	4.02	88.4
Depreciation and interest allowance	0.09	3.1	0.09	2.0
Labour (including management)	0.07	2.5	0.07	1.5
Electricity	0.01	0.3	0.01	0.2
Water	0.004	0.2	0.004	0.1
Medication	0.056	1.9	0.056	1.2
** Insurance	0.01	0.3	0.02	0.4
Repairs and maintenance	0.02	0.7	0.02	0.4
** Mortality (0.092% mortality per day)	0.18	6.3	0.25	5.5
Miscellaneous	0.01	0.3	0.01	0.3
Total costs per additional day of raising goose broiler(70g growth per day for the average of males and females)	2.88	100.00	4.55	100.0

* Food consumption of 155g per additional day at slaughter age(average of males and females).

** The value per goose broiler at slaughter age was \$3.88 at 15.7c per kg food, and \$5.45 at 26c per kg food,
for the average of females and males (Israel Egg & Poultry Board, 1984; Speers and Hamre, 1978).

TABLE 3

Economic value (cents) of the traits of goose breeder hens at different production rates related to a rate of 40 hatching eggs

		Hatching eggs per goose hen housed									
		20	30	40	50	60	70	80	100	120	
1											
2											
3											
4											
5	*Additional food per hen (g)	-3476	-1738	0	1738	3476	5214	6952	10428	13904	
6	* Food value (26.0c/kg)	-90.3	-43.2	0	43.2	90.3	135.4	180.8	271.1	361.5	
7	Additional table egg										
8	value (5.5c/egg)	8.3	3.9	0	-4.4	-8.3	-12.7	-16.5	-24.8	-33.0	
9	** Hen cost(c)	4318	4358	4400	4440.8	4482	4522.9	4564.3	4646.3	4728.5	
10	Hatching egg cost(c)	215.9	145.3	110.0	88.8	74.7	64.6	57.1	46.5	39.4	
11	Value of additional hatching										
12	egg/goose broiler (c)	17.411	7.729	4.314	2.749	1.901	1.387	1.057	0.67	0.467	
13	Hatchability (%)	65	66	67	68	69	70	71	73	74	
14	Goose broiler number/hen										
15	(5% mortality reduced)	12.4	18.8	25.5	32.3	39.3	46.6	54.0	69.4	84.4	
16	Value of additional 1x										
17	hatchability or										
18	fertility/goose broiler(c)	5.217	3.407	2.504	1.963	1.605	1.349	1.159	0.894	0.737	

* Average egg weight = 160 g and the additional food intake per egg = 173.8 g (Barnstein et al. 1979)

** Goose hen cost of 40 hatching eggs = 844 (Israel Egg & Poultry Board, 1984).

Table 4

The relative economic values of traits versus a genetic improvement of ten hatching eggs at various levels of production in a goose broiler enterprise

Trait	Number of hatching eggs per goose hen housed									
	20	30	40	50	60	70	80	90	100	120
Fertility/hatchability (%)	33.4	22.7	17.2	14.0	11.8	10.3	9.1	8.2	7.5	6.3
Goose broiler mortality (%)	33.9	28.3	15.8	10.1	7.0	5.1	4.0	3.1	2.5	1.7
Food utilization (%)	32.9	29.1	16.2	10.4	7.2	5.2	3.9	3.5	2.5	1.8
Eviscerated yield (%)	17.1	7.6	4.2	2.7	1.8	1.3	1.0	0.8	0.7	0.5
Number of days to fixed marketing weight	56.4	17.0	9.5	6.0	4.2	3.1	2.3	1.8	1.5	1.0
Body weight gain (g) equivalent to one egg	332.2	118.9	66.4	42.3	29.2	21.3	16.3	12.8	10.3	7.2

Table 5

Annual expected genetic gains (ΔG) of traits and their relative economic importance in an integrated goose broiler enterprise

Trait	h ¹	S	ΔG^{**}	Economic value based of annual genetic gains	
				Food price 26¢/kg (Israel) \$1000	Food price 15.7¢/kg (U.S.A.) \$1000
Fertility/hatchability	0.10	2.0%	0.28	8.6	2.1
Mortality	0.05	1.8%	0.13%	4.3	1.1
Food utilization (independent)	0.25	20%	73(3.0%)	95.6	23.2
Fat-Eviscerated yield**	0.50	1.0%	0.7±0.43=0.3%	37.2	9.0
Growth rate	0.40	33%	186.5g(4.5%)	145.4	35.3
Egg number ***	0.35	27.4	2.28(1.3%)	94.0	22.8
Feathers	0.25	10	3.5g(3.7%)	26.9	6.5
Total				412.0	100.0
				304.3	100.0

¹ Based on a 5,000 tonnes goose meat enterprise, 40 hatching eggs per goose hen and about 4 kg per goose broiler.

** ΔG h¹ 18 (Falconer, 1961), assuming 1ml.4 except for egg number 1=0.475 (Shalev, 1984).

*** Improvement in eviscerated yield due to reduced fat.

**** based on dam selection only.

10. Genetic-economic evaluation of traits in a goose liver enterprise

Calculations were based on the above results for all traits involved, with additional data for the estimated costs of cramming goose for one additional day of c21.7.

Under these assumptions it seems that in the goose liver enterprise the traits involved have the following approximated relative value: liver weight (49%), food utilization (28%), egg number (15%) and feathers (5%).

All other traits are of minor genetic-economic value (3%).

E2. THE NUTRITION OF GEESE DURING DIFFERENT STAGES OF AGE AND PRODUCTION1. THE GROWING PERIOD1.1. Protein, essential amino acids and glycine requirements of the growing gosling

The dietary requirements for protein and amino acids of the growing gosling (0-7 weeks of age) were calculated according to body composition (3), maintenance needs (1) and the absorption rate of amino acids from feeds (4).

The diets were formulated by least-cost programming, according to the calculated requirements for amino acids, with or without minimal glycine + serine requirements. The relative weight of skin and feathers is very high in the gosling (3). These tissues contain high levels of glycine and serine. Glycine can be readily synthesized by birds, but during periods of rapid growth the rate of synthesis may not satisfy the needs for tissue growth. In the present investigation, the diets formulated without minimal requirements of glycine + serine were supplemented with various amounts of glycine, and fed to growing goslings.

The calculated requirements for protein and essential amino acids were lower than those suggested for growing broilers and turkeys. The requirements (g/Mcal ME) at 0-2, 2-4 and 4-7 weeks of age respectively, were: lysine 3.7, 2.0, 1.8; methionine + cystine 2.0, 1.6, 1.2; protein 60.8, 39.0, 32.0.

Table 1.1.1. Body weight gain, food intake and food utilization in goslings as affected by dietary protein and glycine levels (all diets contained 3000 kcal ME/kg).

Glycine supplementation g/kg	Dietary glytser g/kg	Age 0 - 2 weeks		Food intake g	Gain/Food
		Protein g/kg	Body-wt gain g		
0	18.0	188	715	971a	0.740b
1.5	19.5	188	689	907ab	0.761b
3.0	21.0	188	653	879ab	0.743b
6.0	24.0	188	651	837ab	0.784b
0	24.0	230	681	801b	0.862a
Glycine supplementation g/kg	Dietary glytser g/kg	Age 2 - 4 weeks		Food intake g	Gain/Food
		Protein g/kg	Body-wt gain g		
0	13.0	134	1230bc	2990ab	0.412
0.75	13.7	134	1337a	3193a	0.422
1.5	14.5	134	1283ab	3069ab	0.420
3.0	16.0	134	1277abc	3097ab	0.410
0	16.0	150	1178c	2880b	0.410

Values with different superscript letters were significantly different ($P < 0.05$).

Up to 2 weeks of age glycine supplementation caused a slight reduction in food intake and body-weight gain, which was negatively related to the glycine concentration in the diet ($r = -0.96$ and -0.89 respectively). Later this depression was compensated for, and at the age of 4 weeks no significant differences between the groups were found in food intake and body weight (Table 1.1.1).

From 4-7 weeks the performance of geese fed the calculated diet (236 kcal ME/%protein) was compared to a commercial diet (193 kcal ME/%protein) (Table 1.1.2).

Table 1.1.2. Body weight, food intake and utilization of geese fed experimental or commercial diets between 4 and 7 weeks of age.

	<u>Experimental diet</u>	<u>commercial diet</u>	<u>SEM</u>
Protein (%)	12.7	13.5	
Kcal ME/ Kg	3000	2600	
Kcal ME/ % protein	236	193	
Body wt. gain (g)	1721	1553	48.6
Food intake (g)	5625	5600	12.7
Gain/food	0.306	0.277	0.008
Protein intake (g)	714	756	12.0
Gain/protein	2.41	2.05	0.104
Energy intake (Mcal ME)	16.9	14.5	0.65
Gain/Mcal ME	102	107	1.46

Geese fed the experimental diet grew better and utilized food and protein more efficiently than geese fed the commercial diet.

In conclusion, it seems that protein can be saved by reducing its concentration to 18.8%, 13.4% and 12.5 % in diets containing 3000 kcal ME/ kg for the ages 0-2, 2-4 and 4-7, respectively, without negative effects on performance.

1.2. The effect of dietary energy and fiber concentration on body weight gain, food intake and utilization, organs weight and fatty liver weight after cramming.

Experiment 1.

Diets containing 3000 kcal ME/kg and 19% protein from 0-2 weeks and 13.5% protein thereafter were diluted with 7 or 15% ground wheat straw (1-2cm), to produce diets containing 2790 and 2550 kcal ME/kg. One hundred and thirty five, day-old goslings were divided into 9 groups of 15 geese each - 3 groups/treatment. Food and water were available all the time. Food intake and body weight were recorded weekly.

Ten goslings from each treatment were fed the experimental diets up to 15 weeks of age and then were forced-fed in order to determine the effect of the treatments on the weight of the fatty liver.

Addition of 15% straw to the diet reduced food intake and body weight gain up to 7 weeks of age, but improved energy and protein utilization (Table 1.2.1). Addition of 7% straw was accompanied by an increase in food intake, concurrent to an improvement of energy and protein utilization (NS).

Between 7 and 15 weeks of age, the geese receiving 15% straw in the diet had a compensatory growth and attained a body weight, similar to that of the two other groups. The total food intake from 0-15 weeks of age was similar in the 3 groups (Table 1.2.1).

The fatty liver weight was slightly improved by the addition of 7 or 15% straw (NS).

Table 1.2.1. Effect of adding wheat straw to the diets of the growing gosling on body weight gain, food intake and utilization and cramming performance.

Level of straw in diet (%)	0	7	15
Kcal ME/kg diet	3000	2790	2550
Food intake (g)	7901	8293	7650
Body wt. 7w (g)	2960a	3040a	2750b
Body wt. gain 0-7w (g)	2870ab	2947a	2661b
Food/gain	2.78	2.81	2.87
Energy intake (Mcal)	23976	23137	19732
Mcal/gain	8.35a	7.85ab	7.47b
Protein intake (g)	1070	1037	841
Protein intake/gain	0.37a	0.35ab	0.32b
Body wt. 15w (g)	4392	4671	4489
Food intake 0-15w (kg)	25.4	26.5	25.7
Body wt. after cramming (g)	8150	7864	7828
Liver wt. after cramming (g)	533	540	552
Days of cramming	32	31	32

Values with different superscript letters were significantly different ($P < 0.05$).

At 7 weeks of age, 5 goslings from each treatment were sacrificed and organs weight were recorded (Table 1.2.2).

Addition of 15% wheat straw to the diet increased consistently the relative weight of feathers, liver and length of the oesophagus (Table 1.2.2). The weight and length of the small intestine were increased by 15% straw but not to a statistically significant degree. All other organs and abdominal and mesenterial fat were not affected by the addition of straw.

Table 1.2.2. Organ size and gastrointestinal contents at 7 weeks of age. (values are given in g or cm per 100g body wt.).

Level of straw in diet (%)	0	7	15
Feathers	10.8b	10.9b	12.6a
Abdominal fat	2.2	2.4	2.2
Mesenterial fat	1.2	1.5	1.3
Liver	1.9b	1.9b	2.2a
Pancreas	0.18	0.16	0.18
Oesophagus wt.	0.32	0.35	0.40
length	0.99ab	0.90b	1.08a
Proventriculus	0.31	0.26	0.33
Gizzard	4.37	3.98	4.15
Duodenum wt.	0.29	0.25	0.27
length	1.12	1.03	1.22
Small intestine wt.	0.99	0.92	1.10
length	5.19	4.90	5.83
Cecum	0.21	0.18	0.24
Colon	0.14	0.15	0.16
<u>Gastrointestinal contents</u>			
Gizzard	0.53	0.54	0.53
Duodenum	0.079	0.077	0.064
Small intestine	0.47	0.44	0.38

Values with different superscript letters were significantly different ($P < 0.05$).

Experiments 2 and 3.

In experiment 2 the effect of adding 7% ground wheat straw to commercial diets calculated to contain 2750 kcal ME/kg and 18.5% crude protein from 0-4 weeks of age, and to a diet containing 2700 kcal ME/kg and 13% crude protein from 4-10 weeks of age was studied.

In experiment 3 the effect of adding ground straw to the commercial mash was compared to free access to unground wheat straw, which was available all the time, but was not mixed with the mash. The same mashes were used in the two experiments. The proximal composition of the diets is presented in Table 1.2.3.

Table 1.2.3. Proximal composition of the diets fed in experiments 2 and 3 (%).

Age (weeks)	0 - 4		5 - 10	
Level of straw	0	7	0	7
Kcal ME/kg (calculated)	2750	2560	2700	2510
Dry matter	87.8	86.0	87.0	85.5
Crude protein	18.5	17.4	15.2	14.2
Ether extract	2.58	2.60	2.08	2.26
Crude fiber	2.95	5.17	3.25	5.70
Ash	5.74	5.37	5.66	5.30
Ca	1.13	0.97	1.32	1.13
P	0.67	0.63	0.55	0.52

In experiment 2, 5 groups of 10 - one day old goslings were allotted to each dietary treatment.

In experiment 3, the goslings were divided into 2 groups of 34 and 33 geese.

In both experiments (Table 1.2.4), inclusion of ground wheat straw into the mash, improved the mash/gain ratio (when zero value was given to the straw) as compared to geese given free access to unground straw, or to those devoided of any straw.

Table 1.2.4. Effect of including 7% wheat straw in the diets of growing geese on the performance during the growing period and at cramming.

	Experiment 2		Experiment 3	
Level of straw in diet	0	7	0	7
No. of geese	50	50	34	33
Initial body wt. (g)	90	90	100	100
Body wt. at 4w. (g)	1780(120)	1720(125)	2590(360)	2390(260)
Food intake to 4w (g)	3350(225)	3220(192)	5050	4950
Food/gain to 4w	1.98(0.25)	1.97(0.20)	2.02	2.15
Mash/gain* to 4w	1.98(0.25)	1.83	2.02	2.00
Body wt. at 10w (g)	3910(215)	3890(255)	3910(520)	3940(430)
Food intake to 10w (g)	19030(761)	16900(1448)	15790	16230
Food/gain to 10w	4.98(0.36)	4.47(0.32)	4.13	4.21
Mash/gain* to 10w	4.98(0.36)	4.13	4.13	3.92
After cramming				
Body wt. (g)	7720(571)	7670(670)	—	—
Liver wt. (g)	550(148)	623(186)	709(62)	730(49)
cramming (g)	550(148)	623(186)	709(62)	730(49)

@ Free access to unground straw. * When zero value is given to straw. Values in parenthesis are SE.

Free access to unground straw probably did not encourage the geese to consume as much straw as was consumed when ground straw was mixed with the mash. Body gain was not affected by the addition of straw. The geese, which received ground straw in their diets during the growing

period, had bigger fatty livers after cramming in both experiments. The results of these experiments confirmed those of Experiment 1.

Experiment 4.

It was shown in Experiments 1 - 3 that the addition of ground wheat straw to the diet of goslings during the growing period improved food utilization and the weight of fatty livers obtained after cramming. Since the addition of ground wheat straw is not practical in feed mills, an experiment was carried out in which dietary fiber was supplemented by the inclusion of wheat bran and barley. The control was a commercial diet (15% protein, 2700 Kcal ME/kg, 4.5% fiber). The experimental diet contained 12.6% protein, 2435 kcal ME/kg, 6.1% fiber.

A factorial experiment was designed. Each diet was fed to 12 groups of 10 geese each: 3 groups of white males, 3 of white females, 3 of grey males and 3 of grey females. The experiment was carried out from 25 to 84 days of age. The results are presented in Table 1.2.5.

No interactions were observed between the dietary treatments, sexes or lines (white vs. grey) of geese. The growth obtained by the geese fed the high fiber diet did not differ significantly from the controls. In the geese fed the experimental diet, food intake and food/gain ratio was increased by 6% and 10%, respectively, but energy/gain ratio was similar in both groups. These results confirm those of Stevenson (5) who reported that body weight gain was not affected by reducing dietary energy concentration from 3100 to 2630 kcal ME/kg.

Table 1.2.5. Effect of fiber enriched diet on growth, food intake and food and energy utilization by male and female geese, white and grey types, between 4 and 10 weeks of age.

	Males	Females	White	Grey	Control	Experiment
Body wt. 25d (kg)	2.06	2.00*	2.02	2.04	2.02	2.05
Body wt. 84d (kg)	5.04	4.55***	4.76	4.83	4.83	4.76
Body wt gain (kg)	2.98	2.55***	2.74	2.78	2.81	2.72
Food intake (kg)	19.15	17.65***	18.44	18.37	17.89	18.91**
Food/gain	6.48	6.93*	6.80	6.61	6.39	7.02**
Energy/gain	16.58	17.73*	17.38	16.93	17.25	17.06

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

The fatty liver weight following cramming was slightly reduced (NS) by feeding the high fiber diet during the precramming period (657+144 and 625+170g, means+SD, in the control and experimental groups, respectively).

From the above study, it was concluded: 1) The favorable effect obtained by the inclusion of ground straw into the diet is not due only to increased dietary fiber. 2) Geese are able to maintain normal growth when fed low energy diets due to compensatory food consumption.

1.3. Feeding mash or pellets to growing goslings from 4 to 10 weeks of age.

A commercial diet (15% protein and 2700 Kcal ME/kg was fed as mash or as 4mm pellets. Each diet was fed to 6 replicates of 10 gosling each (3 replicates - males and 3 - females). The results are presented in Table 1.3.1.

Table 1.3.1. Body weight gain, food intake and food utilization of goslings fed mash or pellets.

	Mash		Pellets		Main effects:		
	M	F	M	F.	sex	treat- ment	sxt
Body wt. 4w. (kg)	1.71	1.52	1.70	1.53	xx	NS	NS
Body wt. 10w. (kg)	4.23	3.63	4.27	3.85	xx	NS	NS
Food intake (kg)	12.4	11.7	11.8	12.0	NS	NS	NS
Body wt. gain (kg)	2.53	2.13	2.56	2.35	x	NS	NS
Food/gain	4.92	5.42	4.58	5.11	x	x	NS

M-males; F-females.

Food utilization was improved consistently by feeding pellets ($P < 0.05$). No significant differences were observed in food intake or body weight gain between the groups fed pellets or mash. Body weight gain and food utilization were consistently higher in males than in females.

Fourty geese fed mash or pellets during the precramming period were crammed and the fatty livers were weighed. The fatty livers weights were 712 and 721 for mash and pellets, respectively (NS).

2. QUALITATIVE AND QUANTITATIVE FOOD RESTRICTION PRIOR TO CRAMMING.

The minimal body weight of geese grown for cramming is about 3.5 kg. The geese may attain this weight at the age of 8-9 weeks. Due to the seasonal reproductive cycle, the main egg production is between December and April, and young geese are not available for cramming at the fall and winter, when the demand for fatty liver is at its peak. Constant supply of goose liver is possible by cramming older animals. Different holding diets and feeding regimes, designed to maintain a constant body weight from 8-9 weeks until cramming, were studied.

2.1. Qualitative restriction of food intake.

Experiment 1.

The experimental diets were: 1) corn and sorghum (1:1) supplemented with minerals and vitamins according to NRC (1977).

2) The same as 1 but the grains were ground. 3) Commercial mash containing 13.5% protein and 2450 kcal ME/kg, amino acid content were formulated according to Nitsan et. al. (3).

The geese had free access to food and water. Each diet was fed to 5 replicates of 4 geese each, from 8 to 16 weeks of age. At the age of 16 weeks some geese from each treatment were crammed in order to estimate the effect of the precramming diet on liver weight.

Table 2.1.1. Body weight, food intake and cramming performance of geese fed a commercial diet or whole or ground corn and sorghum grains (1:1) during 8 weeks prior to cramming.

	Commercial diet	corn:sorghum grains (1:1)	
		whole	ground
No. of geese	20	20	20
Body wt. 8w (g)	3150	3200	3200
Body wt. 16w (g)	4725a	3280b	3450b
Body wt. gain (g)	1575a	80b	250b
Food intake (kg)	12.06a	9.78b	10.26b
ME intake (Mcal)	29.5	30.3	31.8
Cramming performance			
Initial body wt.(g)	4880a	3820b	3630b
Final body wt.(g)	8380a	7490b	7080b
Body wt. gain (g)	3500	3670	3450
Liver wt.(g)	766a	542b	530b
Liver grade*	1.33	2.72	1.40
Days of cramming	35.8	36.1	35.0

*Livers were graded from 1 to 5: 1= grade A and 5 = rejected.

Figures bearing different superscripts are significantly different $P < 0.05$.

Consumption of diets 1 and 2 was lower by about 20% than of diet 3, but energy intake of diets 1 and 2 was slightly higher (NS). (Table 2.1.1).

In spite of the higher energy intake, the geese fed the grain mixture maintained a constant body weight. The geese fed the commercial mash gained about 1.5 kg during the experimental period. Feeding grains during the precramming period depressed the fatty liver weight ($P < 0.05$), while body weight gain during cramming was similar in all groups.

From the above study it was concluded that the weight of the geese at the start of the restriction period should be higher than in the present study, or a diet, balanced in amino acids, should be fed before cramming (pregavage).

Experiment.2.

The second experiment was started when the geese attained a body weight of 4 kg or over at the age of 10 weeks. Group 1 received whole grain mixture (corn:sorghum 1:1) up to cramming at 20 weeks of age. Group 2 received the same diet up to 17 weeks and later on they received the commercial diet. Group 3 received the commercial diet throughout the experimental period.

As in experiment 1 the geese receiving the grain mixture during the whole experimental period maintained body weight with a slight, non significant weight gain. (Table 2.1.2). The geese receiving the commercial diet gained 817g from 10-17 weeks. From 17-20 weeks a marked compensatory growth was observed in the group fed grains up to 17 weeks of age and the commercial diet thereafter. The weight of all the groups at start of cramming was higher than in Experiment 1 and no statistically significant differences were observed between the weights of the fatty livers of the different treatments.

It was concluded: 1) Although feeding grains only was not effective in restricting food intake, it reduced body weight gain. 2) Feeding grains only to geese weighing at least 4 kg caused a slight reduction in the liver weight after cramming (NS) and feeding the commercial diet prior cramming improved the fatty liver weight (NS). 3) The depressed energy utilization of the geese fed grains only in Experiments 1 and 2 could be due to a lower digestibility of the grain diet since it was reported that addition of soybean meal to corn increased the secretion of digestive enzymes and the digestibility of the corn (2). It could be also due to a higher body fat deposition in geese fed grains only.

Table 2.1.2. Body weight(g), food intake (kg) and cramming performance of geese fed a commercial diet or whole grains (corn:sorghum 1:1) with or without a pregavage period of 3 weeks with a commercial diet.

	Commercial diet	corn:sorghum grains (1:1) (+commercial diet) (-commercial diet)	
No. of geese	15	15	15
Body wt. 10 w	4250	3973	4233
Body wt. 17 w	5067	4133	4400
Body wt. gain 10-17 w	817a	160b	167b
Body wt. 20 w	5273a	4880b	4613b
Body wt. gain 17-20 w	206b	747a	213b
Body wt. gain 10-20 w	1023a	907a	380b
Food intake	19.4	19.8	19.3
Mcal ME intake	47.6	58.2	69.2
<hr/> Cramming Performance <hr/>			
No. of geese	14	10	13
Initial body wt.	5329	4880	4669
Final body wt.	8807	8246	8477
Body wt. gain	3478	3446	3808
Liver wt.	643	620	600
Liver grade*	2.0	1.8	1.8
Days of cramming	30.6	32.1	32.4

*See footnote to Table 2.1.1.

2.2 Quantitative restriction of food intake.

Experiment 1.

Three levels of quantitative restriction of a commercial diet were studied. The feeding levels from 10 to 14 weeks were: 100g/d; 150g/d and ad libitum. The diet contained 13.5% protein and 2450 kcal ME/kg. Three weeks before cramming (14-17 weeks of age), all the geese were fed ad libitum. The performance of the geese is presented in Table 2.2.1.

The geese restricted to 100g/d maintained their body weight from 10 to 14 weeks of age. The geese restricted to 150 g/d gained 333g and those fed ad libitum consumed an average of 330g/d and gained during this period 1059g.

Table 2.2.1. Effect of food restriction between 10-14 weeks of age on body weight gain and on performance during cramming.

	<u>Ad libitum</u>	150g/d	100g/d
No. of geese	12	12	12
Body wt. 10w (g)	4208	4375	4416
Body wt. 14w (g)	5267	4708	4417
Food intake 10-14w (g/d)	330	150	100
Body wt. 17w (g)	4783	4425	4425
Food intake 14-17w (g/d)	140	166	208
Body wt. gain 10-17w (g)	575	50	9
Food intake 10-17w (kg)	12.9	7.3	6.8
ME intake (Mcal)	31	20	19
<u>Cramming performance</u>			
No. of geese	12	12	11
Initial body wt. (g)	4860	4450	4480
Final body wt. (g)	8590	7750	8010
Body wt. gain (g)	3690	3300	3530
Liver wt. (g)	504	550	527
Liver grade*	1.77	2.18	2.18
Days of cramming	32.7	32.7	34.7

*See footnote to Table 2.1.1.

When the restricted geese were released to ad libitum feeding (14-17 weeks of age), those initially restricted to 100g/d consumed a daily average of 208g and those restricted to 150g/d consumed 166g/d. The geese which were fed initially ad libitum had, during this period, the lowest food consumption (140g/d). The total food intake during the experimental period was 6.8, 7.3 and 12.9 Kg/goose. The cramming performance was similar in the different treatments.

It may be concluded that quantitative restriction is more effective than qualitative restriction, since in this regime 4-5 Kg food/goose could be saved without negatively affecting liver weight after cramming.

3. THE NUTRITION OF THE LAYING GOOSE.

3.1. Protein and energy consumption of laying geese having access to separated protein rich or energy rich diets.

Egg production in geese is low and sporadic, therefore the nutritional needs differ widely between individual geese.

Experiment 1.

This experiment was intended to inquire whether laying geese can equilibrate their nutrient intake according to their needs in a free choice situation.

A group of 20 laying geese and 6 ganders were allowed free access to two diets: one diet was composed mainly of grains and contained 8.9% protein and 3140 kcal ME/kg, whereas the second diet was composed mainly of soybean-meal and fishmeal, containing 37.5% protein and 1920

kcal ME/kg. The concentration of minerals and vitamins was the same in the two diets. The experiment lasted for two months.

A close relationship was found between the consumption of the high-protein diet and the rate of laying (Fig. 3.1.1).

Figure 3.1.1. Egg production (▲), high protein (■) and high energy (□) diet intake of laying geese offered split diet.

Experiment 2.

In the previous experiment it was indicated that the laying goose was able to regulate her intake of nutrients according to egg production, when separate protein and energy sources were offered simultaneously. This study was carried out on a flock of geese without replicates. The present study was carried out on individual layers.

Fourteen females were divided into 2 groups according to their egg production during the previous year. The geese were housed in individual pens. Seven geese received split diet as in experiment 1, while 7 geese received a commercial layer diet (16% protein, 2700 kcal ME/kg). Feed consumption, egg production and egg weight were recorded weekly, and body weight monthly, from 7 weeks before the start of laying to 23 weeks after the 1st egg for each individual layer.

The results with individual geese confirmed that the geese were able to select protein according to egg production (Fig. 3.1.2.).

Figure 3.1.2. Egg production ($\blacktriangle$), high protein ($\triangle$) and high energy ($\blacksquare$) diet intake and body weight ($\bullet$) of laying geese offered split diet.
 Egg production (∇), food intake ($\square$) and body weight ($\circ$) of laying geese offered a commercial diet.

While the consumption of the commercial and high energy diets increased gradually during the 7 weeks prior to the start of laying, the increase in the consumption of the high protein diet was initiated one week before the start of laying. The anticipation of high protein diet intake to egg production was maintained for 10 weeks. During this period (From one week before to 10 weeks following the start of laying) the correlation coefficient between number of eggs and high protein diet intake the previous week, was $r=0.70$. No relationship was found between egg production and high protein diet intake during the same week ($r=0.19$). After 10 weeks of laying, egg production and high protein diet intake reached a steady state, the week to week variation was very low and the correlation between egg production and high protein diet intake was nil ($r=0.18$).

No correlation was found between egg production vs. high energy or commercial diet intake.

Protein intake was lower in the split diet than in the control group up to one week before the start of laying. During the week prior to the start of the laying period, protein intake markedly increased and surpassed that of the control. Total protein intake, during 23 weeks of laying, was 16% higher in the split diet group than in the control one.

Energy intake was similar in both groups. When the geese were exposed to a choice situation, the energy: protein ratio varied according to their physiological needs (Table 3.1.1).

Table 3.1.1. Protein and energy intake prior and during egg production of laying geese offered conventional or split diets.

	7-1 wks before laying		1wk before laying		1-23 wks after start of laying	
	split diet	control	split diet	control	split diet	control
Protein intake (g/week)	161 (12)	209 (23)	375 (10)	305 (9)	338 (11)	291 (6)
Energy intake (kcal/week)	3450 (263)	3535 (392)	5463 (220)	5152 (200)	4791 (107)	4930 (103)
E/P ratio (kcal/%Prot)	214	169	146	169	142	169

Numbers in parenthesis are SE.

During the prelaying period (up to 1 week before the 1st egg), the average concentration of protein in the feed consumed by the experimental geese was 13.3%. It increased to 18.7% in the week prior to the 1st egg and was 19.1% during the 23 weeks of laying.

The average egg weight was similar in both groups (168 g). The slight increase in the number of eggs and egg mass in the experimental group (about 7%) was not statistically significant (Table 3.1.2).

The energy utilization for egg production was improved in the experimental group.

The geese were able to maintain a higher body weight (Fig.3.1.2) and egg production with a lower energy intake (Table 3.1.1).

We assume that protein utilization may also be improved by formulating the split diets according to the needs in amino acids for maintenance and/or egg production.

Table 3.1.2. Performance of laying geese offered conventional or split diet.

	Split diet	Control
Eggs/layer/week	2.96 (0.13)	2.78 (0.07)
Egg mass/layer/week	500. (21.5)	468 (13.5)
Protein intake, g/egg	118. (6.33)	106 (3.23)
Protein intake, g/g egg	0.70 (0.04)	0.63 (0.02)
Energy intake Kcal/egg	1689 (86.6)	1797 (55.8)
Energy intake Kcal/g egg	9.98 (0.49)	10.7 (0.34)

Numbers in parenthesis are SE.

In this work the choice capacity for protein only was studied since the Ca and P levels were similar in both diets.

3.2. The effect of feeding simultaneously a layer and a grower diet to laying geese.

Experiment 1.

From previous studies it was concluded that the laying goose can equilibrate its nutrients intake in a free choice situation.

A practical way to apply the ability of the goose to consume nutrients according to its needs is to supply simultaneously a layer and a grower diet.

Geese, after being kept in dark rooms during 8 weeks in order to initiate egg production, were used. Two groups, one of white geese and one of grey geese, were assigned to each dietary treatment (23 females and 11 males). The control group had free access to a layer diet (16% protein, 2900 kcal ME/kg, 2.4% Ca). The experimental group had free access to the layer diet and to a grower diet (14.5% protein, 2875 kcal ME/kg, 1.1% Ca). All groups had free access to lime stone. Food intake, egg production and fertility were recorded during 3 months (April - July, 1985). The results are presented in Table 3.2.1.

Table 3.2.1. Food intake, egg production and fertility of laying geese fed a layer diet or fed simultaneously a layer and a grower diet. (Averages of 2 replicates/treatment).

	Control	Cafeteria
Food intake (kg/goose)		
Layer diet	26.5	7.3
Grower diet	—	19.5
Total	26.5	26.8
Egg production/goose		
Total eggs	24.2	26.8
>140g	23.0	25.2
Fertility (%)	67.9	80.9

Total food intake was similar in the control and experimental groups. Some improvement in total egg production was observed. The percentage of eggs bigger than 140g (suitable for incubation) were similar in both treatments (95% and 94% in the two groups). Fertility was consistently better in the experimental groups.

Experiment 2.

A similar experiment was carried out with 6 replicates per treatment. Four females and two males were assigned to each replicate. The experiment lasted 5 months (December - April, 1986). The results are shown in Table 3.2.2.

Table 3.2.2. Food intake, egg production, fertility and hatchability of laying geese fed a layer diet or fed simultaneously a layer and a grower diet.
(Means of 6 replicates during the experimental period, December - April).

	Control	CV	Cafeteria	CV	P(f)
Initial body wt. (kg)	4.458	15	4.512	14	NS
Final body wt. (kg)	4.146	13	4.568	17	
Body wt. gain (g)	-303	20	56	13	
Food intake (kg)					
Layer diet	227	21	80	15	0.000
Grower diet	—	—	185	20	0.000
Total	227	21	265	27	0.03
Grower/Layer	—	—	2.31	20	
Total egg production	172	46	193	53	NS
>140g	130	59	141	68	NS
>130g	156	59	178	56	NS
<130g	12	16	9.7	7.7	NS
rejected	3.7	3.8	3.5	2.7	NS
% of total eggs:					
>140g	75.9	32.0	73.1	23.0	NS
>130g	90.7	18.8	92.3	58.0	NS
<130g	6.58		5.03	70.0	NS
rejected	1.92	112	1.82	71.0	NS
Fertility (%)	83.0	7.4	80.6	6.8	NS
Hatchability (%)	74.9	18.9	82.0	9.1	NS

The improved performance observed in the previous experiment was confirmed in the present one, although not to a statistically significant degree.

In a free choice situation, total food intake was increased by 17% ($P>0.03$). The experimental group consumed about 2 fold grower diet than layer diet. The geese fed the split diets were able to maintain their body weight during the laying period inspite the 12% increase in egg production. The geese fed the layer diet only, lost about 8% of their initial body weight during the laying period. Some improvement was observed in hatchability.

4. NUTRITION DURING CRAMMING.

4.1. The effect of adding various fats to a force-fed diet on goose fatty liver.

Since hepatic steatosis in the crammed goose is mainly due to excessive energy intake, addition of fat to the diet could be beneficial. In the present work the effect of different fats added to the cramming diet on the fatty liver size, fatty acid composition of the liver fat, feed utilization and the duration of cramming period were determined.

Goose fat, poultry fat, beef tallow or soybean oil were each added to a basal diet (87% corn, 10% soybean meal, 3% vitamins and minerals). In 5 experiment geese were crammed with these fat supplemented diets or with the basal diet.

The fatty acid composition of the livers was not affected by supplementotion with fats at the assayed levels (Table 4.1.1).

Table 4.1.1. Fatty acid composition of supplementary fats and of the liver fat obtained by feeding diets, each supplemented by different fat.

Supplemented fats	Fatty acids (%)							
	14:0	16:0	16:1	18:0	18:1	18:2	18:3	20:4
In fat sources								
Goose	0.5	23.6	4.1	8.0	54.2	9.5	—	—
Poultry	—	22.9	10.2	5.1	42.1	17.2	0.8	—
Beef tallow	—	32.5	2.9	24.0	37.4	1.0	—	—
Soybean	—	11.5	—	4.3	28.3	49.5	6.9	—
In livers (means of 3-5 livers / treatment)								
2% goose	0.6	21.6	2.9	14.4	56.7	2.8	—	—
5% goose	0.4	21.5	2.7	14.9	57.6	2.2	—	—
5% poultry	—	21.3	2.7	14.4	59.2	1.7	—	0.2
5% tallow	—	20.5	2.4	16.9	57.1	1.9	—	0.4
5% soybean	—	21.1	2.3	16.2	56.8	2.6	0.1	0.4
No addition	0.5	23.9	2.4	16.7	54.6	2.1	—	—

Fat supplementation (2-5%) always increased liver weight by 10%. Goose and poultry fat allowed to shorten the average cramming period and improved feed conversion and body weight gain.

Beef tallow and soybean oil had no effect on the cramming period and soybean oil did not improve feed utilization (Table 4.1.2).

Table 4.1.2. Effect of various fats individually added to the basal diet of crammed geese, on liver weight, cramming period and feed utilization

Exp. No.	Fat source	% fat added	Liver weight (g)	Body weight gain (g)	Cramming period (d)	Food intake (kg)	kg food/kg liver	Energy intake (kcal ME)	Energy intake/kg liver	No. of geese
1	Goose	0	703 (15)	3200 (42)	34.0 (0.31)	22.6	32.1	73.7	105	85
		2	780(*) (61)	3648(*) (18)	33.1 (0.62)	22.1	28.3	74.2	95	20
		5	805(*) (17)	3580 (64)	30.9(*) (0.63)	20.7	25.7	72.6	90	20
2	Poultry	0	650 (14)	3420 (53)	31.3 (0.29)	22.4	34.5	73.0	112	85
		2.5	715(*) (15)	3694(*) (52)	31.0 (0.36)	20.2	28.3	68.3	95	65
3	Beef tallow	5	741(*) (16)	3790(*) (60)	30.4(*) (0.26)	18.0	24.3	63.1	86	65
		0	508 (13)	3599 (56)	35.7 (0.32)	20.1	39.6	65.5	129	100
4	Soybean oil	5	559(*) (16)	3460 (68)	35.9 (0.51)	19.1	34.1	67.8	121	30
		0	512 (13)	3602 (54)	35.6 (0.33)	20.2	39.5	65.9	129	100
5	Poultry	5	558 (18)	3414 (71)	36.0 (0.71)	23.2	41.6	81.3	146	10
		0	551 (15)	3930 (51)	35.4 (0.35)	20.1	36.4	65.5	119	85
5	Soapstock 70:30..	5	624(*) (18)	4020 (56)	33.7 (*) (0.37)	18.5	29.6	64.9	104	85

Figures in parenthesis are the Standard Error of the Mean.

(*) Statistically significant from the parallel control (no fat supplementation)

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E3. THE EFFECT OF PHOTOPERIODISM, ARTIFICIAL INSEMINATION AND HOUSING ON
EGG PRODUCTION AND FERTILITY (ISRAEL)

1. Development of practical techniques for semen collection from ganders
and for insemination of laying geese

a. Obtaining semen by the electrical stimulation method.

Several experiments were conducted in which various electrical stimulation methods (different electrode locations and amperage) were used. Although some successful ejaculations occurred, it was finally concluded that this method cannot be considered as a practical technique for collection of semen. In most cases, the ganders exhibited a marked active resistance, and in those cases in which semen was indeed obtained, it contained also urine and fecal material. It was therefore decided to apply and improve the abdominal massage method for collection of semen from cocks and toms - originally developed by Burrows and Quinn (1937) - to the gander.

b. Development of the abdominal massage method for semen collection as a practical technique for ganders.

Based on several experiments, the following are the main steps that should be taken, and which appear to be conducive for achieving optimal results:

- 1) Prior to onset of the "milking" procedure, it is recommended to trim the feathers around the cloaca, in order to eliminate direct contact between semen and feathers.
- 2) Two experienced technicians are needed for the "milking" procedure.
- 3) One technician, sitting on a chair, holds the gander firmly on his leg, while the head of the gander is located under his arm.
- 4) Massage is carried out, using both hands simultaneously, on the back of the gander towards the cloaca, and in the abdominal region towards the ventral aspect of the cloaca.
- 5) After 50-70 seconds of continuous massage, an "inflation" of the cloacal area can be easily felt, indicating the beginning of erection.
- 6) At this particular time a collecting tube is brought near the cloaca by the second technician. Strong pressure should then be applied to both sides of the dorsal part of the cloaca (by the first technician), which usually causes the protrusion of the erected penis.
- 7) The erected penis is directed to the special test tube (with a wide opening). The second technician performs a gentle massage on the erected penis as well as of the ventral opening of the cloaca.
- 8) Semen is normally ejaculated a few seconds later, accompanied a sudden "over stretch" of the penis.

Microscopic examination of semen samples obtained by the described method revealed an absence of fecal or urinal contaminations. The method described thus proved to be practical and therefore was adopted for future experiments.

c. Insemination procedure

A technique was developed which was based on that routinely used in artificial insemination of chickens and turkeys. The insemination is carried out by two technicians. One technician holds the female goose under his arm, pushing the tail in the dorsal direction with his one hand, while pressing the abdominal wall with the other. This induces the protrusion of the vagina. At that point the second technician gently introduces the insemination tube into the vagina, to a depth of 2.5-3.5 cm. Simultaneously the first technician eases the pressure on the abdominal wall, causing the vagina to draw back into the abdominal cavity while engulfing the tube and withdrawing it as well. With this method, there was no need to use a speculum in order to direct the insemination tube into the vagina, as commonly used in other experiment stations.

2. Housing laying geese in cages

Twenty-three geese were housed in individual cages and were inseminated artificially with the semen of 3 ganders.

The performance obtained is summarized in Table 2. These results indicate that geese housed in cages perform poorly, their rate of egg and gosling production being less than half of what is expected of geese housed in single floor pens. An additional group of geese did even worse. Consequently, this part of the project will not be continued.

Table 2

The performance of laying geese housed in single cages during October to May*

Hen-housed production (eggs)	25
Hen-day production (eggs)	27.2
Fertility (%)	64.6
Hatch of fertile eggs (%)	52.0
No. of goslings per goose	12.9

* Averages of 23 geese.

3. Egg production and fertility in geese housed in individual pens

The average egg production of 90 female geese, kept in individual pens, each with one gander, was 23.5 eggs|female|season, as compared to 45.7 eggs in breeders kept in a flock.

In another experiment, 14 females and 2 males were kept in individual pens. Each day one female was transferred to one of the males. This regime lasted for 3 months. During the following 3 months, a male was transferred each day to a pen of another female. Two ganders served 14 females in this way. The average fertilization rate during the two periods was 76% (Tables 12,13).

It was observed that sexual activity of the males was decreased after 9 weeks of intense libido and increased again after 10 days of rest. The fertility of the ganders was not affected by the different methods that were used.

Table 12.

Percent of fertile eggs from female geese kept in individual pens and were transferred to ganders once a week.

<u>Gander No.</u>	<u>eggs/female</u>	<u>October</u>	<u>November</u>	<u>December</u>	<u>Total</u>
1	23.8	94.4	92.7	59.2	77.0
2	28.1	71.4	87.1	65.7	74.7

Table 13.

Percent of fertile eggs from female geese kept in individual pens to which ganders were transferred once a week.

<u>Gander No.</u>	<u>eggs/female</u>	<u>January</u>	<u>February</u>	<u>March</u>	<u>Total</u>
1	28.0	89.8	82.8	67.5	82.1
2	24.1	82.2	86.3	35.0	71.9

4. Photostimulation and regulation of egg production in geese

4.1 Supplementation of artificial light from various sources at two intensity levels

Two trials were performed in order to evaluate the influence of source of light and its intensity on the egg production of geese. The first trial was conducted in pens on floors bedded with litter and with access to yards, hence there was an exposure to some direct sunlight during the day. The second trial was carried out in individual cages placed inside an open shed, hence the birds were exposed to diffuse daylight rather than to direct sunlight.

Trial 1

This trial was reported in detail in Poultry Science (Pyrzak, Snapir, Robinson and Goodman, 1984), hence only the main points will be cited here.

Two lines of geese were used in this trial: the white (W) and Gray (G) lines.

One month before the start of lay, the geese of each line were randomly divided into three light treatment groups, which were subdivided and exposed to one of two different light intensities, 20 and 50 lx.

Each of the 12 experimental groups were divided into four replicate pens with four geese per pen. The light sources were:

- 1) Cool-white (C) fluorescent 40W lamp.
- 2) Vita-Lite (V) Fluorescent 40W lamp, (sunlight simulating light spectrum).
- 3) Tungsten (T) 60 and 100 W bulbs.

Results are presented in Table 14.

Table 14.

Total egg production of two lines of geese exposed to different light sources and intensities.

Source light ¹	20 lx			50 lx			Total		
	W ²	G	Total	W	G	Total	W	G	Total
C	71.39 ^a	70.98 ^a	71.18 ^a	45.16 ^a	69.69 ^a	57.57 ^a	58.43 ^a	70.33 ^a	64.38 ^a
V	64.27 ^{ab}	45.60 ^b	54.94 ^b	51.88 ^a	50.83 ^a	51.35 ^a	58.07 ^a	48.22 ^b	53.14 ^b
T	49.63 ^b	60.88 ^{ab}	55.25 ^b	40.92 ^a	52.81 ^a	46.86 ^a	45.27 ^a	56.84 ^b	51.06 ^b
Total	61.76	59.15	60.46	46.08	57.78	51.93	53.92	58.46	56.19

a,b Means within a column followed by different superscripts are significantly different ($P < .05$).

1 Cool White (C) and Vita-Lite (V) fluorescent and tungsten (T) filament incandescent lamps.

2 White (W) and Grey (G) geese.

Results of Table 14 show that C light at 20 lx is the preferable combination for light supplementation for laying geese. However, there is some interaction between light source, or intensity, and the two lines of geese. A similar interaction between genetic background and light intensity was reported in laying turkeys (Nestor and Brown, 1972).

The significant advantage of the lower light intensity (20lx) over the higher one (50 lx) may possible be explained as due to a slower development of light refractoriness in the geese exposed to less light.

Trial 2

The individual cages were placed in an open shed which was subdivided into 3 sections separated by solid walls. Each section of the shed received its light supplementation of 4 to 6 hours daily to natural day light from one of the following 3 sources: Vita-Lite (V) fluorescent 40 W lamps, Cool-White (C) fluorescent 40 W lamps, or from tungsten (T) incandescent 60W bulbs. Light intensity was uniform at 60 lx. Each section contained 23 females and 3 ganders, each housed in an individual cage, with free access to food and water and under a regimen of artificial insemination. Egg production started on December 13th and the trial was terminated on March 20th.

The results obtained with regard to egg production, fertility and hatchability are summarized in Table 15.

Table 15. The performance of geese exposed to 3 light sources

Light source	No. of geese		No. of eggs produced				Fertility (%)**	Hatchability		No. goslings, hen-housed goose
	Initial	Average	Total	hen-day	hen-housed	Small eggs*		All eggs	Fertile eggs	
V	23	22.5	683	30.6	29.7	20.2	60.2	49.4	82.1	14.7
C	23	21.1	591	28.1	25.7	21.7	64.2	52.9	82.4	13.6
T	23	19.8	451	22.8	19.6	25.9	69.3	53.8	77.6	10.5

* weighing less than 140 g., hence unfit for incubation.

** See text.

Results of Table 15 show a decided advantage of the fluorescent lamps over the incandescent bulbs, with no significant difference between the V and the C lights, although egg production tended to be superior due to the former. Fertility was rather low, because these were almost the first attempts at artificial insemination by the staff.

In both trials the incandescent tungsten light tended to be inferior to fluorescent light sources for stimulating egg production in laying geese. The difference between the results of the two different fluorescent lights in the two trials may be due to the difference between these trials as far as the exposure to direct sunlight is concerned. In the first trial, the geese were exposed to some direct sunlight in the yards, hence the sunlight stimulating spectrum of Vita-Lite could not contribute anything beyond the effect of light per se. In cage geese, on the other hand, the exposure during the day was to diffuse daylight only, hence the supplementary V light might have produced some advantage, on the assumption that the sunlight spectrum has some special beneficial effect in stimulating egg production over that of the spectra of artificial lights.

4.2 Shifting egg production of geese to late-summer and fall

Geese are seasonal egg layers, whereas the market requires a steady year-round supply of goose products. Light restrictions may be one method of obtaining out-of-season egg production.

The present experiment involved 3 treatments and 2 strains of 2 year old geese, in a 3x2 factorial design. The treatments consisted of (a) control (untreated), (b) forced molt and (c) light restriction. The forced molt was induced by with-holding water for 2 days and feed for 10 days; thereafter feed was restricted to 100 g/goose/day for an additional 20 days. The light-restricted geese were housed during 6 weeks in force-ventilated, light-tight pens having a diurnal cycle of 6 hours light and 18 hours of darkness.

Each one of the above 6 treatments were replicated 3 times, 10 females and 3 males per replicate. The trial started in the middle of April.

The results obtained are summarized in Table 1. The differences between the managerial treatments were not significant, due to marked variations between the replicate lots, but the strain effects were highly significant ($p < 0.01$). Both force-molting and light restriction enabled off-season egg production, with a slight numerical advantage for the latter regimen.

The satisfactory egg production of the control geese was completely unexpected, since normally they cease laying by the end of May. No satisfactory explanation can be advanced at this stage, except for the suggestion that we might be dealing with the phenomenon of "induction", i.e. the visual and vocal effects of layers on non-layers.

Table 1

The effects of force-molting and light restriction on the egg production of geese of the White (W) and Grey (G) strains during the months of June-August*

Performance per goose	<u>Control</u>		<u>Force molt</u>		<u>Light restriction</u>		<u>Average**</u>	
	W	G	W	G	W	G	W	G
Eggs	15.2	12.0	16.0	8.0	17.4	12.3	16.2	10.8
Fertile eggs	11.7	3.6	12.1	3.7	12.7	7.0	12.2	4.8
Goslings	7.6	1.3	8.5	1.9	7.7	3.7	7.9	2.4

* Averages of 3 replicates of 10 females + 3 ganders each.

** Averages of 9 replicates. The differences between the strains were highly significant ($p < 0.01$).

In the follow-up trial the use of light restriction for off-season egg production has been further explored by comparing durations of 6, 8 and 10 weeks.

4.3 Regulation of egg production in geese with light restriction at 6, 8 , 10 weeks vs. force molt

The main purposes of this study were to determine the optimal duration of light restriction and to compare the latter to a forced molt, both methods being applied in order to obtain off-season egg production of geese during summer and fall.

Experimental Procedure

The trial was started at the beginning of April and lasted 12 months. It used geese which were approximately 1½ years old of age and just had finished their first laying season. They belonged to 2 strains: the grey strain (G) and the white strain (W), both of the same age.

The light-restricted geese were housed in force-ventilated light-tight pens having a diurnal cycle of 6 hours light and 18 hours darkness. Each pen contained 14 female geese and 5 ganders, allowing 4.4 birds per sq.m. Each treatment was replicated by either 2 or 4 such pens, half for each strain. After cessation of the light restriction all pens received artificial illumination supplementing natural daylight for a total of 15 hours light per day.

All geese were weighed 4 times during the experiment: at the start of the trial, when reaching a production rate of ½ egg|goose|week, at the peak of egg production and when production had declined to ½ egg|bird|week.

The 6 treatments of the trial were as follows:

1. Light restriction during 10 weeks - 2 replicates.
2. Light restriction during 8 weeks - 2 replicates.
3. Light restriction during 6 weeks, preceded by a 10 day period of feed withdrawal in order to cause a forced molt - 2 replicates.
4. Forced molt by withdrawal of feed as described on page 17 of previous report - 4 replicates.
5. Feed restriction of 150 g|goose|day during the 12 months of the experiment - 4 replicates.
6. Control - 4 replicates.

Results

The results obtained are summarized in Tables 16-19 Fig. 1. Table 16 indicates that best post-treatment performance was obtained following light restriction during a 10-week period. These results require further confirmation by additional trials. In the present trial the rate of fertility was higher than in the previous experiment, possibly because of an increased male|female ratio and|or due to releasing the males from their light restriction 2 weeks earlier than the females of the same treatment. The hatchability of fertile eggs was very low immediately after the start of egg production (52% during June), but improved gradually to over 85% during August. Reports from the field substantiate this findings. Egg

production of the geese not subjected to light restriction was surprisingly high during the off-season months.

On the basis of the entire laying period (Table 17), there exists an obvious advantage for the light restriction of 8-to-10 weeks over the shorter period and over the forced molt, the lowest production being caused by feed restriction during the entire experiment. Apparently 150 g|goose|day are insufficient to support optimal production.

Fig. 1 presents the monthly egg production curves of treatments 1-3 (light restriction) and 6 (control). Light restriction brought about a 2-months unseasonal peak during the summer months, followed by a steep decline during late-summer and fall, and a new seasonal peak during December-February. The control geese, on the other hand, had a low production during summer and fall, with a gradual improvement during winter. These curves are very similar to those obtained in the previous trial (not presented in the previous report).

Apparently there is no strain X photoreceptivity interaction, with both strains showing a response to light restriction, but the graded response to the duration of the period of light restriction tended to be stronger with the grey line, which, however, was markedly inferior to the white line in its rate of egg production (Table 18), in full

agreement with several previous comparisons.

Table 16. The performance of geese during June, July and August

Preceding treatment Treatment No.	Light restriction			Forced Molt 4	Feed ** Restriction 5	Control 6
	10 weeks 1	8 weeks 2	6 weeks 3 *			
Eggs per goose	16.3	12.3	11.5	9.9	9.3	7.1
Fertile eggs***	12.0	8.7	7.9	6.3	5.9	5.5
Goslings***	7.5	5.5	4.8	4.3	4.3	4.4

*Preceded by 10 days of starvation to induce molting.

**150 g/goose/day during the entire experiment.

***Per goose.

Table 17. The performance of geese from June 1st. to March 31st*

No. of treatment	1	2	3	4	5	6
Eggs per goose	66.3	67.0	65.0	61.2	46.8	56.1
Fertile eggs	51.5	49.4	41.5	42.8	32.6	43.5
Goslings	39.8	40.9	32.3	34.9	26.4	35.6

*See footnotes to Table 1.

Table 18. The performance of the white (W) and gray (G) strains of geese during June, July and August

Treatment No. Strain	1		2		3		4		5		6	
	G	W	G	W	G	W	G	W	G	W	G	W
Eggs per goose	12.7	19.4	7.8	18.1	4.6	18.9	3.2	16.4	0.5	17.1	0.2	13.9
Fertile eggs	9.6	14.1	4.5	14.1	2.9	13.3	1.4	11.1	0.1	11.5	0.2	10.7
Goslings	6.3	8.6	2.6	9.3	1.8	8.0	1.1	7.4	0.1	8.2	0.1	8.7

Table 19. Body weights (gram) of both sexes at various stages of the experiment *

Treatment No.	1		2		3		4		5		6	
Sex	M	F	M	F	M	F	M	F	M	F	M	F
Initial weight**	5500	4800	5800	4760	5450	4950	5175	5060	5714	4994	5614	4811
After starvation					4650	4200	4630	4260				
After light restriction	5750	4670	5725	4650	5450	4910						
$\frac{1}{2}$ egg/goose/week	5300	5450	5560	5330	5450	5650	5965	5610	5314	5123	5633	5493
Peak production	5900	5145	5850	5000	6000	5300	5713	5185	5307	5032	5750	4935
$\frac{1}{2}$ egg/goose/week	6290	5080	6250	4860	6100	5200			5500	5485	***	***

* Only representative samples were weighed.

** At the start of the treatments

*** The average egg production of the control geese did not decrease to $\frac{1}{2}$ egg/goose/week until the end of experiment.

Figure 1. Egg production of geese under various light restrictions

According to Table 19, during the 10 days of starvation (in order to induce molting) female geese lose about 750-800 g. body weight and ganders approximately 550-600 g. With regard to those subjected to light restriction, the females lose about 100-150 g. during this period, whereas the ganders tend to show a mixed trend. Following light restriction and until an initial stage of egg production (1 egg/goose/week) there appears a period of marked increase in body weight for the females with an opposite trend for the ganders. Beginning with the latter stage, through the peak of production and during its decline, the laying geese lose weight while the ganders gain weight.

Discussion

This is the second trial in which a forced molt failed to induce a satisfactory off-season summer egg production, hence this method apparently does not justify further study in this respect. In contrast, light restriction of 6-10 weeks (especially the longer duration) again demonstrated its ability to bring about off-season production during the months June through August, presumably by eliminating photo-refractoriness (developed during the spring months) and thus restoring photoreceptiveness.

The egg production of the geese in treatments 5 and 6 was rather unexpected, even though its rate was markedly lower than that following light restriction. There is no obvious explanation for this unusual phenomenon, seen also in the previous trial, but it may be hypothesized that we are dealing with the behavioral effect of layers on non-layers in their close proximity. This supposition may be worth following up.

During this experiment the sexual development of several ganders was examined, including the weighing of testes. On the day on which the males were released from their light restriction they appeared sexually completely degenerated, but after about two weeks under a 15-hour per day light regimen they seemed fully recovered. These observations emphasize the importance of terminating light restriction of males before that of females, which seem to recover their productive ability quicker following this treatment than do the former.

Summary

The rate of production of the white line of geese is markedly higher than that of the grey line.

This is the second trial in which, on one hand, off-season egg production during July and August was induced by means of light restriction during a 8-to-10-week period, and on the other hand a forced molt failed to accomplish this aim. Following light restriction ganders appear to

recoover sexual activity at a slower rate than female geese their laying capability.

.hereas usually there is hardly any egg production during the summer months, this is the second time that laying geese (due to light restriction) appeared to induce some egg production in neighboring geese.

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4.4 The Effect of Daylength on the Duration of the Egg Production Period in Geese.

Introduction

From the point of view of domestication, geese can be considered as still being in a rather primitive and "uncivilized" stage, and the short and very seasonal period of egg production may be the direct outcome of this situation. It might be hypothesized that the rapid development and the intensity of photorefractoriness in laying geese is the main reason for their short laying season. If this assumption is correct, then shortening daylength - rather than adding hours of artificial illumination, as customary - should delay the onset of photorefractoriness, thus lengthening the laying period and with it increasing the number of eggs produced.

Several recent studies appear to support the above assumption. Thus, Robertson and Merritt (1979) compared egg production under a constant photoperiod of 10 hours light and 14 hours dark (10L:14D) to that under simulated natural day length, under Canadian conditions. Both Chinese and Hungarian geese exposed to only 10 hours light per day laid more eggs over an extended laying period in their pullet year than the group under natural conditions.

Elminovska-Wenda (1984) of Poland cites a German study (1981) with German and White Italian geese in which a considerably better egg production was obtained with an 8-hour day than with daylengths of 12 and 16 hours. In the Polish study 324 White Italian female geese and 72 ganders were kept on natural daylight (starting with $7\frac{1}{2}$ hours on December 24th), or this daylength was increased by 15 min/day until constant daylengths of 8 and 12 hours were attained. Mortality (about 5%), fertility (87%) or hatchability of fertile eggs (70%) were not affected by these 3 treatments, which lasted 8 months. The geese of treatment 3 (12 hrs/day) started to lay on the 9th day of the experiment, whereas those of treatment 2 (8 hrs/day) started 3 weeks later. Treat-

ment 3 averaged 16 eggs during the first 2 months vs. 4.5 eggs for treatment 2, but production ceased 3 months earlier. Accordingly, on a photoperiod of 8L:16D production averaged 67.6 eggs or 39.5 goslings, whereas the corresponding results of the 12L:12D regimen were 52 and 28.4, respectively.

Grunder (1984) of Canada used $1\frac{1}{2}$ -year old geese of Chinese and a synthetic strains, housed in a windowless building containing 48 pens of 5 females and one male per pen. They were moved from the range to this building in January and given 7 hours of light per day. Two weeks later, in half the pens the photoperiod was changed abruptly to 10L:14D, and in the other half duration of light was increased 15 minutes per day for 16 days, then 15 minutes per week until a photoperiod of 13L:11D was attained. The experiment lasted 172 days from the start of the photoperiod treatments. Length of period up to the first egg was 36 and 48 days ($p < 0.01$) for the 13 and 10-hour light treatments, respectively, but survivor egg production was 32 and 40 eggs ($p < 0.01$), respectively. There was a photoperiod x strain interaction ($p < 0.05$), the advantage in favor of 10 over 13 hours of light per day being 10% for the lower-producing strain and only 6% for the better strain, parallel to the results of Robertson and Merritt (1979). Although the geese exposed to a 10L:14D photoperiod were 7 days slower in starting production than those exposed to 13L:11D, they produced an average of 8 more eggs, suggesting that long daylengths may bring geese into and out of production more quickly than short day lengths. In an additional experiment with geese in their first year of lay, they responded similarly to an abrupt increase of light from 7 to 10 hours per day and to a gradual increase in light to a 11L:13D photoperiod with regard to egg production as well as fertility.

Materials and Methods

Geese of strain 70, which had been rejected for further breeding work after their first egg production season on the basis of their progeny test for liver size, were housed in 10 pens, 15 females and 6 males per pen. On the first of October they were changed from natural daylight (slightly less than 12 hours) to a photoperiod of 12L:12D.

One week later, in half the pens (control geese) the photoperiod was increased weekly by 30 minutes until it reached 17L:7D in the second week of December, as is customary in many commercial reproductive flocks. In the experimental pens these light increases were stopped on October 15th when daylength had reached 13 hours light per day, and this photoperiod of 13L:11D was maintained until the end of the trial (May 16th).

Results

The average number of eggs produced by the geese on the two photoperiod treatments are summarized in the diagram. Unfortunately, no production records are available for October, the first month of the trial, but it can be assumed that during this period the control geese laid approximately 4 eggs per head and the experimental birds about 2 eggs; these suggestions are not included in the figures of the diagram.

The data of the diagram show that at the end of December (3 months after the start of the experiment) the control geese had an advantage of 5 eggs over the experimental treatment (25.1 vs. 20.2 eggs). During January, however, the production trends reversed, and the advantage at the end of the month decreased to 3 eggs.

The control geese ceased egg production about 2 months before the experimental geese, and during the last 2 months of production before the final cessation the average rate of production of the former was less than 1

egg per week. The final results after an experimental period of $7\frac{1}{2}$ months was an average of 58.9 eggs for the experimental photoperiodic treatment compared to 36.2 eggs for the traditional lighting regimen.

Discussion

The results obtained indicate that a long daylength induces a rapid start of egg production, but also its early cessation, in full agreement with the previous studies detailed in the introduction. Employing relatively short and long daily photoperiods in 2 flocks, or 2 halves of one flock, on the same reproductive farm may thus make it possible to extend the duration of the peak of egg production and to counteract to some extent the seasonality of lay in geese.

The data presented in this report may be construed as suggesting that the onset of photorefractoriness is determined not only by the duration of artificial illumination in terms of days or weeks, but apparently also by the total number of hours of light (natural or artificial) per day. On the rough basis of 5 vs. 7 months of production for the 17 and 13-hour photoperiods, respectively, the total hours of light were 2570 and 2755, respectively. Assuming that the start of the steep decline in egg production at the beginning of February and April are indications for the beginning of photorefractoriness in the two photoperiodic treatments, then the total number of hours of light until this point were 1900 and 2340 for the 17L:7D and 13L:11D light regimens, respectively. The meaningfulness of these values or their accidental nature can be determined only by additional experiments.

Conclusions

In contrast to laying hens, for which a relatively long daily photoperiod seems essential for the maintenance of a high and persistent egg production,

FIGURE 1. The effect of a constant 13 hours light versus 17 hours light

the situation with regard to laying geese appears to be exactly the opposite, with a relatively short daily photoperiod indeed delaying the onset of egg production and its peak, but also causing a longer duration of production and with it an increased number of eggs. This phenomenon may be due to slowing down the development of photorefractoriness.

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E4. NUTRITION AND PHOTOPERIODISM DURING DIFFERENT STAGES OF AGE AND PRODUCTION (U.S.A.)

INTRODUCTION:

The commercial production of geese is generally less advanced than chickens, ducks or turkeys. While geese produce high quality meat, large livers for highly prized pate and excellent down for warm clothing, their capability to compete with other poultry species is handicapped by several factors.

Until recently and to some extent currently, goose production was considered as small and peripheral farm enterprise. Under this system there was a variation in age, ranging from very young up to 5 years for processing. This variation in age, size and feathering made it impossible for processors to merchandise a uniform quality product. The situation is beginning to change, however, with the larger more intensive operations specializing in first year geese, including breeder geese.

The potential for goose production can be vastly improved by earlier maturity, increased egg production, higher fertility and hatchability, uniform feathering and reduced abdominal fat. These traits have low heritability and selective breeding has not been attractive to commercial breeders. Understandably selection has focused on size and growth traits which have resulted in reasonably rapid pay off results.

The negative genetic and phenotypic correlation between reproductive traits and body size and muscling in both broiler chickens and turkeys has been overcome to a considerable extent by judicious application of nutrition systems and photoperiod management. Restrictive feeding programs and light management have made it

possible to attain acceptable levels of egg production and fertility in male and female chicken broiler breeders. Turkeys differ from chickens in that restrictive feeding during the prebreeder period has not been successful (El Halawani et al, 1975 and Noll et al, 1981). However, light management promoting earlier maturity and prolonged egg laying along with artificial insemination has improved poult yield to an acceptable level. Restrictive feeding during the prebreeding period for geese has not been explored for possible positive conditioning for improved reproduction.

The objective of the Minnesota goose research is to determine if application of the two major environmental factors, nutrition and photoperiod can improve reproductive capacity. The general principles of light management and nutrition for chickens and turkeys are well known but the fundamental response of geese to these factors are obscure. In fact results of this project indicate some major response differences from both chickens and turkeys.

The general principle of high protein to energy content in the ration of young birds with subsequent reduction in the protein to energy level holds for geese as in other species. However, the most efficient levels for growth, fat deposition, feathering and reproduction for geese are poorly defined. Geese are considered to be grazers and in some situations this is an asset, but it appears that green plant utilization in intensive operations is not feasible. Knowledge about improvements through environmental control in reproductive traits is a distinct possibility and could be attained rapidly and utilized by the industry in a short time. Ultimately genetic selection will be necessary for improvement and it is expected

that information about the optimum environment for selection will improve progress by either exposing here-to-fore hidden genetic variation or reduce the environmental component in phenotypic variation.

OBJECTIVES:

The broad objective was to evaluate nutrition and photoperiod management practices under complete confinement for effects on growth, fat deposition, feathering and reproduction. Under the following specific experimental objectives:

1. To determine the optimum protein-energy level requirements for the
 - a. growing period, prebreeder period, breeding period and recycled breeders.
2. To determine the response to photoperiod regimes during the growing, prebreeder, breeder periods and recycling.
 - a. To determine optimum age of sexual maturity for subsequent optimum reproduction using photoperiod management:
 - b. To determine if restricted diurnal light regimens will prolong the laying season.
 - c. To determine the performance levels of recycled breeders.
3. To determine the responsiveness of male and female geese to stimulatory light increments by measuring the photoperiodically-induced rise in serum luteinizing hormone.
4. To determine the changes in luteinizing hormone prior and during the reproductive period.

MATERIALS AND METHODS

Facilities:

A unit with 16 pens specifically designed and constructed for confinement production of geese was used for experimental evaluation. The unit is capable of four independent light management environments, including intensity and duration. There are four pens in each light controlled block allowing independent nutrition or light regimes or factorial designs. The pens are floor type with rice hull litter with a raised 1 1/2 meter wide, wire covered lagoon with a watering device at the rear of the pen. This design has worked very well for confinement of geese.

EXPERIMENTAL STOCK:

Beginning Spring, 1983 and each succeeding year, large type White Embden goslings were secured when needed from a local breeder, (Schiltz Goose Breeding Farm, Inc.). This stock has been selected for growth and reproduction for several generations and is believed to be one of the top performing stocks in the U.S.

MEASUREMENT OF RESPONSE:

Body weight, feathering score, age at maturity in days, egg production, hormone levels and other appropriate data were recorded according to sex, age, and treatment.

YEAR I - NUTRITION and PHOTOPERIOD

Nutrition - Growing period design:

Day-old Embden goslings (Anser anser domesticus), were randomly assigned to 4 blocks of 4 pens (2.5m X 8.5m) with 18 birds. Sex separate pens, 2 per block, were maintained. All birds were legbanded and toe clipped at 1 day and wingbanded at 2 weeks. Body weight and feed consumption were recorded weekly to 7 weeks and thereafter at 11 and 16 weeks. Mortality was recorded weekly.

All rations were formulated with corn and soybean meal and offered ad libitum as a mash. Composition (Table 1) and calculated analysis (Table 2) are given. Starter rations (0-3 weeks) also contained animal-vegetable fat. Male and female goslings were fed GS20 or GS18 from 0-3 weeks. GG18 or GG16 were fed from 3-7 weeks and GG14 from 7-11 and GG12 from 11-16 weeks.

Lighting - Growing period design:

Day old Embden goslings were placed on continuous 24 hour light until 6 days of age. At 1 week of age each block of 4 pens was changed to 1) "natural" day length (constitutes seasonal daylight hours:modified weekly), 2) 16L:8D, 3) intermittent, (2.5L X 5.5D) or 4) intermittent (1.5L:2.5D). Birds remained on this lighting schedule until 16 weeks of age. Light intensity was reduced to 2 foot candles from 1-16 weeks as a means to prevent feather picking.

RESULTS:

Nutrition - Growing period:

From 0-7 weeks, male goslings fed the 20-18 sequence had heavier body weights than male goslings fed the 18-16 sequence (Table 3). The difference observed at 7 weeks, however, converged by 16 weeks. Female goslings exhibited a similar body weight response. They had heavier weights at 7 weeks but differences were indistinguishable at 16 weeks. Heavier mean weights for females were observed for the 18-16-14-12 sequence compared to the 20-18-14-12, a reversal from the males. Female goslings fed the higher protein sequence were as heavy as males fed the lower sequence at 3 weeks, but by 7 weeks, all male groups were heavier than the females.

Table 4 shows an overall greater rate-of-gain for males compared to females fed the 20-18-14-12 dietary regime. Both males and females fed the 18-16-14-12 sequence had a higher rate-of-gain from 5-7 weeks than those fed the other diets.

As shown in Table 5, females fed the 20-18 sequence had reached 35% of their 16 week weight by 3 weeks, and at 7 weeks, 80%. Birds fed the 18-16 sequence had reached 30% by 3 weeks and 77% of their 16 week adult weight by 7 weeks. Males, however, fed the 20-18 sequence had reached 29% and 74% by 3 and 7 weeks, respectively. By 7 weeks, both groups of females are nearer their 16 week adult weight than either group of males.

Goslings housed with intermittent lighting (Table 6) had heavier body weights at 3, but not 7 or 16 weeks, than birds with natural day length or 16L:8D. Female goslings fed the higher regime had greater

feed consumption from 0-3 but not 3-16 weeks (Table 7). Males had greater feed consumption from 0-7 but not 7-16 weeks. All birds fed the lower dietary regimes had lower feed consumption from 0-7 but not 7-16 weeks (Table 6). Male goslings had greater feed consumption than females for ages including both dietary regimes. Mortality did not appear to be nutritionally dependent.

Lighting - Growing period:

By 3 weeks of age, goslings housed under IL(1.5 X 2.5)6 had heavier body weights than did either the IL(2.5 X 5.5)3 or the two continuous programs: 16L:8D and "natural" day length. At 7 and 16 weeks, however, the continuous schemes: 16L:8D and natural day length showed heavier body weights than did either of the intermittent lighting programs. There appeared to be no advantage of one lighting scheme over another for 0-16 week weight gain. Light intensity, 2 foot candles, appeared to reduce feather picking problems associated with high intensity confinement rearing. Mortality did not appear to be light quantity or intensity dependent.

Nutrition - Prebreeder period design:

Immature female Embden geese, 16 weeks of age, 6 birds/pen, were offered a corn and soybean meal diet ad libitum. The mash contained 12% protein and 2800 kcal/kg ME and was fed from 16 weeks of age to photostimulation at 32, 36, 40 or 44 weeks of age. Mortality was recorded weekly.

Lighting - Prebreeder period design:

The same immature female Embden geese, 16 weeks of age, 6 birds/pen, were kept under 6 hours of continuous light 18 hours dark on at 2 foot candle intensity. This schedule remained effective until age of photostimulation beginning 32, 36, 40 or 44 weeks of age (see Year II: Breeder).

RESULTS:

Nutrition - Prebreeder:

The 12% protein 2800 kcal/kg ME, holding ration was nutritionally adequate for maintaining the 16 week old birds until breeder photostimulation. Bird density, 6 adults/pen, also appeared to be satisfactory. Mortality was not nutritionally dependent.

Lighting - Prebreeder:

Immature Embden females were housed under 6 hours continuous light at 2 foot candle intensity. Light quantity appeared adequate for maintenance. Intensity seemed to reduce feather picking problems associated with high intensity confinement situations.

YEAR 11 - NUTRITION and PHOTOPERIOD

Nutrition - Breeder period design:

Female Embden geese at 16 weeks of age were randomly assigned to 4 blocks of 4 pens (2.5m X 8.5m) (6 birds/pen) per dietary treatment. Adult females were fed a corn and soybean meal diet (Table 8) containing either 12%, 13%, 14%, or 15% protein with 3,000 kcal/kg ME at 32, 36, 40 or 44 weeks of age. Calculated analysis is also shown. Egg production, duration of lay and mortality were recorded weekly.

Lighting - Breeder design:

Female Embden breeders were housed under 6L:18D from 16 weeks to age of photostimulation. At 32, 36, 40 or 44 weeks of age lighting was increased to 16L:8D and maintained at 2 foot candle intensity. This lighting schedule remained in effect until experiment termination. Egg production, duration of lay and mortality were recorded.

RESULTS

Nutrition - Breeder:

Egg production began a week following photostimulation for all Embden females (16L:8D) at 32, 36, 40 and 44 weeks of age (Table 9). Duration of lay varied from 9-15 weeks. Nutrition did not appear to affect weeks in production. The 12% protein diet with 3000 kcal/kg ME supported approximately 12 eggs/goose for the 32 week breeders. The

13%, 14% and 15% protein diets supported 16.0, 18.8 and 18.4 eggs/goose, respectively. Females photostimulated at 36 weeks produced more eggs/goose for each dietary treatment during their laying cycle compared to the 32 week birds. The 36 week females on the 12% protein diet had the lowest number of eggs/goose (13.6) while the 13% protein diet supported 18.1 eggs/goose and the two highest protein levels 14% and 15% supported 19.3 and 24.3 eggs/goose during the 1st laying cycle. At 40 weeks, 16L:8D photostimulation the 12% protein diet again supported only 12.5 eggs/goose, the lowest of the treatments. The 13%, 14% and 15% protein diets improved egg production, increasing to 23.2, 25.8 and 25.0 eggs/goose, respectively. Breeders photostimulated in concordance to "natural" day length were exposed to 16L:8D at approximately 44 weeks. The 12% protein diet was superior for egg production compared to the younger photostimulated birds. There was no improvement with the 13%, 14% or 15% protein diets fed to 44 week birds compared to 36 and 40 week birds. Overall the 15% protein diets supported the best egg production while the 12% diet supported the lowest number of eggs. Egg weights were variable for age of photostimulation, protein levels and their interaction. No trends were observed (Table 10).

Lighting - Breeder:

Egg production began within a week following photostimulation (16L:8D) for all age groups: 32, 36, 40 or 44 weeks. Light intensity (2 foot candles) reduced feather picking problems associated with intensive rearing situations.

YEAR III - NUTRITION and PHOTOPERIOD

Nutrition - Breeder design:

Embden breeder females (1st season), 36 weeks of age, had been reared as described in year I. All birds were fed a 20-18-14-12% protein diet from 0-3, 3-7, 7-11 and 11-16 weeks, respectively. From 16-36 weeks of age the entire flock was fed a 10% protein corn-soybean mash diet. At 36 weeks of age, birds were randomly segregated into one of eight pens (5-6 birds/pen) and assigned a 12, 13, 14 or 15% protein diet containing 3000 kcal/kg ME. Egg production, duration of lay and mortality were recorded weekly.

Lighting - Breeder design:

First season Embden breeders from 16-36 weeks of age were housed under 4L:20D at 2 foot candle intensity. At 36 weeks of age birds were randomly assigned to one of two blocks with a lighting schedule including 10L:14D or 16L:8D. Light intensity was maintained at 2 foot candles.

RESULTS:

Nutrition - Breeder:

The 36 week old Embden breeders offered 15%, 14%, 13% or 12% protein treatments produced 33.0, 27.7, 27.2 and 20.1 eggs/goose, respectively (Table 11). The 15% dietary protein treatment supported greater egg production than did the lower protein levels. Duration of lay extended from 10-18 weeks.

Lighting - Breeder:

The 36 week old Embden breeder females, 1st season, were housed under two lighting schemes (Table 11). The 10L:14D housed females produced 12 more eggs/goose than did the 16L:8D housed females. The 10L:14D scheme is clearly an advantageous light management scheme for 36 week old females. Birds remained in production from 11 weeks for the 16L:8D birds to 15 weeks for birds housed under the 10L:14D lighting regime.

YEAR III - NUTRITION and PHOTOPERIOD

Nutrition - Recycled breeder design:

Second season Embden breeder females recycled from year II, were assigned to two blocks of 4 pens each (5-6 birds/pen). Birds were segregated on the basis of average body weight: A) 5.9 kg and B) 4.8 kg. Geese were fed a 10% protein corn-soybean mash until experiment initiation at 80 weeks of age. Dietary treatments are as described for 1st season females. Birds were fed a 12, 13, 14 or 15% protein diet containing 3000 kcal/kg ME. Egg production, duration of lay and mortality were recorded weekly.

Lighting - Recycled breeder design:

Emden breeder females (2nd season from year II) were housed under 4L:20D from end of 1st season production, approximately 60 weeks of age, to 80 weeks of age. At this time birds were segregated on the basis of average body weight: A) 5.9 kg; B) 4.8 kg. Birds were photostimulated 10L:14D synchronously with the 36 week old, 1st season breeders. Light intensity was maintained at 2 foot candles.

RESULTS:

Nutrition - Recycled breeder:

The 80 week old Emden breeder females (2nd season from year II) remained in egg production for 21 week (Table 12). When fed 15% protein diets, no differences were found in egg production. When a

14% protein diet was fed, the smaller body size birds (4.8 kg) produced approximately 10 more eggs/bird. When protein levels were reduced to 13 or 12%, the larger body size birds (5.9 kg) again produced greater numbers. The larger body size females produced 37, 25, 25 or 20 eggs/goose, on the 15%, 14%, 13% or 12% protein levels, respectively.

Lighting - Recycled breeder:

Embden breeder females (2nd season) photostimulated (10L:14D) at 80 weeks of age showed no advantage in egg production for differences in body weight. There appeared, however, to be a lighting by age interaction. The 36 week old photostimulated females produced 32 eggs/goose while the 80 week old birds produced 27 eggs/goose (10L:14D) (Figure 1). The 80 week old females were in egg production for 21 weeks while the younger females (36 weeks) were in lay from 10-15 weeks.

DISCUSSION: YEAR I

Nutrition - Growing

The growth rate of goslings is very rapid during the initial stages of posthatch development. This has been confirmed by several workers (Saleyev, 1975; Fortin et al, 1983; Hollister et al, 1984; Stevenson, 1985). The reported differences in weight gain, however, could be attributed to age and strain variations. In this experiment weight gain of Embden goslings by 7 weeks of age was approximately 4 kg and 4.6 kg for females and males, respectively. Alternatively, body weight change for Italian Legarth hybrid goslings was 4.89 and 5.6 for females and males, respectively (Stevenson, 1985). This hybrid has a faster rate of gain than do Embdens. Male Embden geese were heavier than female geese which has been validated by several researchers (Bielinska et al, 198 ; Fortin et al, 1983; Hollister et al, 1984; Stevenson, 1985).

By 3 weeks of age, Embden geese have reached 30-35% of their 16 week adult body weight. Comparatively, chicks and poults (Lilja, 1983) by 4 weeks of age have reached only 15% and 5%, respectively, of their mature adult weight. Within 7 weeks, both males and females have gained 73-80% of their adult 16 week weight.

The differences observed in body weights at 7 weeks for Embden goslings was indistinguishable by 16 weeks. This was observed for both male and females comparing either the 20-18-14-12 or 18-16-14-12 dietary regime. While rate-of-gain is reduced from 0-7 weeks for

birds fed the lower dietary sequence, between 7-16 weeks an accelerated gain was observed. It appears the lower protein levels restrict gain during the initial phases of growth although this was not observed to be permanent as indicated by 16 week weights. Saleyev (1975) and Allen (1983) have both reported protein requirements for growing goslings from 0-9 weeks of age. In agreement, this study observes a higher growth rate for geese fed the higher protein diets to 7 weeks of age.

Lighting - Growing period:

Producers in the goose industry are restricted to inefficient light management practices due to lack of qualitative information. Some individuals (Lazar et al, 1980a) have attempted to evaluate photoperiod for growing goslings and its affect on sexual maturity (Lazar et al, 1980b), breeding geese and ganders (Lazar et al, 1981) and reproductive performance (Lazar and Spacek, 1981). Light management for broilers, turkeys and laying hens has been very successful. This indicates that perhaps geese also can be light managed for growth improvement and productive efficiency. Lazar et al (1980a), has found growth differences dependent on both increasing and decreasing light hours. For Embden goslings, differences were insignificant for each of the light regimes. Body weight was superior for the intermittant programs from 0-3 weeks. The natural day length and 16L:8D regimes were superior, however, for gosling gain from 3-16 weeks of age. It appears that the variability in growth rate is too great for light management effectiveness at this time.

DISCUSSION: YEAR II

Nutrition and Lighting - Breeders

The effects of light intensity and light quantity have been studied for the laying hen (Ostrander et al, 1960; Morris, 1967) and the turkey (Nestor and Brown, 1972) for response to artificial lighting schemes for improved reproductive performance. Much less information is available for geese although the onset of production can be advanced with artificial lighting schemes (Hoffman and Hancock, 1950).

In this study mature Embden breeder females were photostimulated (16L:8D) at 32, 36, 40 and 44 weeks of age. All age groups produced eggs within 7 days post stimulatory light as found by Kinney et al (1959). This is an unusual and startling rapid response as compared to either chickens or turkeys.

Rhenish females have been induced to lay as early as 31 weeks of age (Lazar et al, 1979). Under our conditions the 32 week old females did not perform as well as the 36, 40 or 44 week old birds. A similar pattern was secured by Elminowska et al, (1981) when they induced lay at 24 weeks and only 12.4 eggs/goose were produced. At 44 weeks, however, a 10 egg/goose advantage is shown. These birds were housed under 14 hours continuous daylight similar to the 16L:8D used in this experiment.

The 15% protein treatment supported the greatest number of eggs produced for the 36, 40 and 44 week old females. The 15%, 14%, and 13% protein diets when fed to 32 week old birds, supported

considerably fewer eggs with only 18.4, 18.8 and 16.0 eggs/goose. It appears that although the diet is nutritionally adequate for older birds (36, 40 and 44 weeks), these levels are either inadequate for younger females or more likely females of this age are physiologically immature.

Egg size was variable for the 1st season breeders and appeared independent of either age, nutritional or photostimulation treatments. In contrast, Elminowska et al, (1981) found that egg size was greater in females stimulated into production at 44 weeks than those induced to lay at 24 weeks of age.

We were unable to compare light intensity levels as 2 foot candle was maintained throughout in an effort to minimize feather picking problems. Data is needed on the effects of varied intensities as Pyrzak et al, (1983) showed improved egg production for 20 lux environment with 27 week old cross bred geese compared to 50 lux.

DISCUSSION: YEAR III

Nutrition and Lighting - Breeders and recycled breeders

Egg production has been shown to improve in the 2nd, 3rd and 4th year for female breeders. In Pilgrim geese, a 13 egg advantage is seen between the 1st and 2nd year breeder adults (Merritt and Gowe, 1956). Consequently hatchery egg producers tend to rely on the improved egg producing capacity of the yearly recycled breeders even though it results in considerable cost for periods between laying cycles. If the industry were able to improve the egg production of 1st season breeders, this would eliminate the cost disadvantage of holding birds from one laying cycle to the next. Also it would greatly minimize the problem of variable ages for processing that effects quality standards.

While industry has for some time managed geese using long daylight hours this experiment clearly reinforces the advantage of 12 eggs/hen from 10L:14D photoperiod compared to 16L:8D. Our results in the complete confinement environment confirms the same results secured by Robertson and Merritt (1979) and Grunder (1984).

The 15% protein regime supported the highest level of production for 1st season breeders and the same nutritional advantage was found for recycled 2nd season breeders.

The 15% protein diet again supports the greatest level of production for both the large and small (i.e. 5.9 and 4.8 kg) 2nd season breeder. However, when the dietary protein level is dropped 1% from 15% to 14% the large body weight geese drop in performance by 12 eggs/goose. The smaller body weight geese maintain

Prolactin and Luteinizing Hormone Levels in Embden Geese During Photoperiodically-induced Reproductive Cycle

The hormonal profile of luteinizing hormone (LH) and prolactin (PRL) during the reproductive cycle in many birds has been investigated by a number of authors. So far, however, only small amounts of data is available on LH (Campbell et al., 1978. Biol. Reprod. 18, 663), and no data on PRL changes associated with gonadal growth and maturation in geese.

In the present work, we investigated the changes in serum LH and PRL before and after onset of photostimulation in Embden male and female geese. We also compared the changes in the first and second breeder geese.

Effects of Photostimulation (16L:8D) on Serum PRL and LH of Male and Female Embden Geese

The fluctuations in serum PRL and LH in adult male and female geese are shown in Fig. 1. Mean serum PRL levels increased in both males and females after onset of photostimulation. However, the increase was more marked in the females than in the males. The males exhibited a mean maximum increase in PRL levels to 64.5 ± 7.2 ng/ml on day 27 of photostimulation. Thereafter, serum PRL levels declined to 51.1 ± 4.9 ng/ml at the end of the experiment. Females, in contrast, had pronounced fluctuations, the levels reached a mean maximum of 110.9 ± 4.5 ng/ml in 20 days of onset of photostimulation, after which PRL levels plateaued (Days 20-34). The mean PRL level decreased to 52.3 ± 4.7 ng/ml by the end of the experimental period.

There were increases in serum LH levels following onset of photostimulation in both male and female geese. In males, peak value of 6.2 ± 0.5 ng/ml was

observed on Day 34. The level dropped to 1.9 ± 0.1 ng/ml at the end of the experimental period. In females, LH level fluctuated between 4.1 ± 0.1 ng/ml and 5.9 ± 0.5 ng/ml. On Day 84 serum LH dropped to 2.5 ± 0.3 ng/ml.

Effect of Age and Stimulatory Photoperiod Schedule on Serum PRL and LH (Fig. 2)

No differences between 1st year breeders photostimulated with 16L:8D or 10L:14D light regimen were discernible with respect to their PRL level excepting at the end of the experimental period when the 16 hr-birds had lower PRL (48.8 ± 4.9 ng/ml) than 10 hr-birds (95.5 ± 15.7 ng/ml). The 16 hr-group and the 10 hr-group showed the highest PRL level (124.4 ± 12.3 ng/ml and 110.8 ± 3.4 ng/ml) by Weeks 3 and 4 of photostimulation, respectively. Thereafter, there was a gradual decline in PRL level in the 16 hr-birds to 48.8 ± 4.9 ng/ml while the levels in the 10 hr-group fluctuated at a higher levels between 86.4 ± 8.3 ng/ml and 110.5 ± 13.1 ng/ml.

The second year breeders had consistently moderate PRL levels never exceeding 87.1 ± 13.5 ng/ml.

There was variation in LH levels, probably related to ovulatory surges. LH level in the 1st and 2nd year breeders photostimulated with 10 hr of light varied between 5.9 ± 0.5 ng/ml - 8.3 ± 1.1 ng/ml and 4.6 ± 0.7 ng/ml - 6.4 ± 0.9 ng/ml, respectively. In the 16 hr-birds 6.0 ± 0.8 ng/ml and 8.6 ± 1.4 ng/ml during the first 6 weeks of photostimulation. Thereafter, LH level fell to 3.2 ± 0.2 ng/ml at the end of the experimental period.

SUMMARY AND CONCLUSIONS

1. During the growing period male geese are physiologically larger than females.
2. Both female and male geese reach approximately 80% of adult body weight by 7 weeks of age.
3. While there are some slight sex-age interactions the higher protein (20-18) diet gave greater growth gains to 7 weeks of age.
4. Intermittant lighting during the growing period did not have an advantage over "natural" day or 16L:8D for growth to 7 weeks of age and the intermittant light environment resulted in lesser gain from 7 to 16 weeks than the continuous blocks of light and dark.
5. A 12% protein ration appears to be adequate for the prebreeder holding period from 16 weeks of age until photostimulation into sexual activity. The ad lib feeding scheme did, however, result in what we perceive as overly fat birds.
6. In the breeder ration a 15% protein was generally superior to lower levels for all ages and photoperiod regimens.
7. In the first year prebreeders a 6 hour diurnal light was adequate for preconditioning during the 16 week to photostimulation age. In the 2nd year prebreeder conditioning period, 16-week to 36 weeks of age, 4L:20D regimen and 10% protein was satisfactory.
8. Female geese, 32 weeks of age, appear to be physiologically immature for optimum egg production following stimulation. By 36 weeks, however, females are capable of rate-of-lay and persistancy comparable to those photostimulated at a later age.

9. Two foot candles of incandescent source was adequate for photostimulation and maintenance of egg production.
10. Egg production of female geese commences within one week when short day preconditioning is followed by longer day length photostimulation. This rapid maturation is remarkable among domestic poultry.
11. Female geese can be recycled relatively rapidly.
12. Smaller bodied females can perform at a higher rate on a lower protein level than heavier bodied females, probably because less of the ration is required for maintenance of the heavier females.
13. Female geese have a higher prolactin secretion than male geese, whereas, the luteinizing hormone level during sexual activity is about the same. The 10L:14D daily light regimen resulted in a prolonged higher luteinizing profile than the 16L:8D daily light cycle which parallels the egg production cycle of the two light environments.
14. The prolactin levels of both 1st and 2nd year female breeders on 16L:10D light cycle was considerably higher in the first half of the laying season than those on the 10L:14D light cycle and diminished rapidly at the termination of lay.

This project in addition to documenting fundamental information about the nutritive requirements and response to photoperiod of geese, when applied, promises to nearly double egg production in first year female geese. This strongly suggests that from the standpoint of reproduction and product quality breeder geese should be kept only for the 1st year.

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Table 1. Percent composition of dietary treatments for Embden goslings from 0-16 weeks

Ingredients	GS20	GS18	GG18	GG16	GG14	GG12
Corn, ground yellow	62.98	68.47	71.0	77.0	82.0	88.0
Soybean meal, 44	28.82	23.35	26.0	20.0	15.0	9.0
Fish solubles	2.5	2.5	--	--	--	--
Dicalcium phosphate	2.0	2.0	1.5	1.5	1.5	1.5
Calcium carbonate	1.25	1.25	1.0	1.0	1.0	1.0
Salt; iodized	.5	.5	.25	.25	.25	.2
Vitamin premix ¹	.75	.75	.50	.50	.50	.5
Trace mineral mix ²	.10	.10	--	--	--	--
Manganese sulfate (27)	--	--	.025	.025	.025	.0
Zinc oxide (72)	--	--	.0025	.0025	.0025	.0
Niacin (99.5)	.0033	.0033	.0033	.0033	.0033	.0
DL-methionine	.12	.10	.098	.077	.057	.0
Animal Fat	1.0	1.0	--	--	--	--
TOTAL (%)	100.2233	100.0233	100.3788	100.3578	100.3378	100.3

GS83-1

¹Allen, et al. 1983.²Contains: Iron, 2%; Copper, 3000 mg/kg; Manganese, 60,000 mg/kg; Zinc, 60,000 mg/kg; Selenium, 160 mg/kg.

Table 2. Calculated composition of dietary treatments for Embden goslings from 0-16 weeks

Calculated Composition	GS20	GS18	GG18	GG16	GG14	GG12
Protein (%)	20	18	18	16	14	12
Metabolizable Energy (kcal/kg)	3000	3010	3020	3090	3150	3220
Calcium (%)	1.002	.988	.785	.768	.775	.739
Phosphorus (%)	.761	.741	.645	.623	.605	.582
Methionine (%)	.453	.408	.408	.360	.318	.270
Cystine (%)	.309	.280	.286	.254	.226	.194

GS83-1

Table 3. The effect of diminishing protein levels on body weights of Embden goslings from 0-16 weeks¹

Dietary sequence, weeks (0-3) (3-7) (7-11) (11-16)	WEEK							
	1	2	3	4	5	6	7	16
	----- (g/goose) -----							
Females								
20-18-14-12	395.4	1119.7	1875.4	2710.3	3092.9	3662.2	4163.1	5248.
18-16-14-12	365.6	962.0	1654.0	2423.2	2877.0	3548.1	4120.9	5353.
Males								
20-18-14-12	405.9	1224.0	2053.3	2990.8	3518.7	4207.3	4757.5	6488.
18-16-14-12	371.6	1091.2	1878.8	2821.0	3363.7	4138.5	4697.4	6489.
Pooled SE	9.4	16.4	34.2	54.9	60.1	43.9	50.1	45.

¹Four blocks of 4 pens; 18 goslings per pen.

Table 4. The effect of diminishing protein level on rate-of-gain of Embden goslings from 0-16 weeks¹

Dietary sequence, weeks (0-3) (3-7) (7-11) (11-16)	WEEK						
	1	2	3	4	5	6	7
----- (g/goose-day) -----							
Females							
20-18-14-12	41.4	103.5	107.9	119.3	53.3	77.1	66.1
18-16-14-12	37.1	85.2	98.9	110.6	65.0	90.6	78.6
Males							
20-18-14-12	42.6	116.9	118.5	133.9	75.3	93.9	68.5
18-16-14-12	37.7	102.8	112.2	131.3	77.9	108.6	73.1

¹Four blocks of 4 pens; 18 goslings per pen.

WEEKS

%

Table 6. The effect of lighting regime on body weight of Embden goslings from 0-16 weeks¹

Light Regime	WEEKS		
	3	7	16
	(g/goose)		
NATURAL DAY/LENGTH*	1833.1	4529.6	6201.6
16L:8D	1846.7	4483.0	5838.9
IL (2.5 x 5.5)3	1871.7	4293.9	5738.0
IL (1.5 x 2.5)6	1909.0	4454.3	5827.3
Pooled SE	10.4	35.1	43.4

*Constitutes seasonal daylight hours: modified weekly.

¹Four blocks of 4 pens; 18 goslings per pen.

Table 7. The effect of diminishing protein levels on feed consumption of Embden goslings from 0-16 weeks¹

Dietary sequence weeks						
(0-3)	(3-7)	(7-11)	(11-16)	0-3	3-7	7-16
Females						
20-18-14-12				.400 ^{ab}	1.068 ^b	1.315 ^b
18-16-14-12				.369 ^b	1.125 ^{ab}	1.356 ^b
Males						
20-18-14-12				.442 ^a	1.297 ^a	1.551 ^{ab}
18-16-14-12				.412 ^{ab}	1.233 ^a	1.629 ^a
Pooled SE				.0043	.0045	.0156

^{a, b}Column mean superscripts differ significantly ($P < .05$).

¹Four blocks of 4 pens; 18 goslings per pen.

Table 8. Composition and calculated analysis of dietary treatments for Embden breeders¹

Ingredients	GB12	GB13	GB14	GB15
-----%				
Corn, ground yellow	80.2	77.4	74.7	71.9
Soybean meal, 44	7.1	10.0	12.8	15.6
Alfalfa, dehy-17	2.0	2.0	2.0	2.0
Fish solubles	2.5	2.5	2.5	2.5
Fermacto 500	.50	.50	.50	.50
Dicalcium phosphate	1.58	1.53	1.47	1.41
Calcium carbonate	4.97	4.98	4.99	5.01
Sodium chloride	.50	.50	.50	.50
Trace mineral mix ²	.10	.10	.10	.10
Vitamin premix ³	.50	.50	.50	.50

Calculated analysis				
Protein (%)	12.0	13.0	14.0	15.0
ME (Kcal/kg)	3000.0	3000.0	3000.0	3000.0
Calcium (%)	2.3	2.3	2.3	2.3
Phosphorus (%)	.6	.6	.6	.6
Methionine (%)	.24	.25	.26	.27
Lysine (%)	.50	.58	.65	.73

¹Six geese per pen²Contains: Iron, 2%; Copper, 3000 mg/kg; Manganese, 60,000 mg/kg; Zinc, 60,000 mg/kg; Selenium, 160 mg/kg.³Allen et al., 1983.

Table 9. Effect of dietary protein level and age of photostimulation on female Embden breeders¹

<u>Week of Photostimulation²</u>	<u>Dietary Protein Level³</u>	<u>Goose Eggs</u>	<u>Weeks in Production</u>
32	15%	18.4	10
	14%	18.8	13
	13%	16.0	10
	12%	11.8	10
=====			
36	15%	24.3	12
	14%	19.3	10
	13%	18.1	13
	12%	13.6	10
=====			
40	15%	25.0	12
	14%	25.8	14
	13%	23.2	10
	12%	12.5	12
=====			
44	15%	28.7	15
	14%	23.4	9
	13%	20.0	11
	12%	19.0	9

¹ Six geese/pen.

² 16L: 8D; 2 foot candles.

³ 3000 Kcal/kg ME.

TABLE 10. Effect of dietary protein level on range of egg weights for Embden breeder females

Dietary Treatment	WEEK OF PHOTOSTIMULATION			
	32	36	40	44
		(grams)		
12%	140-146	131-160	150-175	143-168
13%	143-160	147-173	147-161	139-182
14%	149-158	149-163	132-158	160-183
15%	139-156	144-160	148-174	160-189

GB83-1

Table 11. The effect of dietary protein levels and light management¹ on egg production of 36 week old Embden breeders²

Dietary protein ³	16L:8D	10L:14D
	-----Egg Production (eggs/goose)-----	
15%	22.8	38.6
14%	20.6	34.6
13%	22.0	31.6
12%	21.6	23.0
SEM	1.43	2.14

¹ Two foot candles.

² 6 geese/pen.

³ 3000 Kcal/kg ME.

Table 12. The effect of dietary protein levels and body size¹ on egg production of 80-week-old Embden breeders²

Dietary protein ³	A: 5.9 kg	B: 4.8 kg
	-----Egg production (eggs/goose)-----	
15%	37.0	37.0
14%	25.0	34.0
13%	25.4	21.8
12%	20.0	15.7
SEM	1.94	2.41

¹ A: 5.9 kg; B: 4.8 kg.

² 6 birds/pen; 10L:14D, 2 foot candles.

³ 3000 Kcal/kg ME.

Figure 1. The effect of dietary protein levels on egg production of 36 and 80-week-old Embden breeder females¹

¹ 6 birds/pen; 10L:14D, 2 foot candles.

² 3000 kcal/kg ME.

F. DESCRIPTION OF COOPERATION

A series of integrated experiments took place in Israel and the U.S.A.

The integrative nature of this proposal permitted the efficient use of birds, facilities and staff for various purposes simultaneously.

Cooperation between the U.S.A. and Israel teams was obtained by mutual planning, summarizing and discussing experiments of breeding, nutrition and management, through mail and visits.

Experiments of the U.S.A. team were carried out in complete confinement, while those of the Israeli team in conventional open houses. Thus, basic and applicative information were obtained, such as for photoperiodism and nutrition.

Photoperiodism

Experiments carried out in Israel showed that light intensity of 20 lux resulted in higher egg production (20%) than 50 lux. On the other hand, the U.S.A. team has shown that a short and constant daylight of 10 hours was advantageous, in egg production, over a 16 hours light regime. An additional experiment carried out in Israel has shown that in an open house, a minimum constant light of 12 hours was advantageous over a system, commonly used, of increased daylight to 17 hours.

These results, together with those published in the literature, suggest that in contrast to laying hens, geese are refractory to light. Therefore, the use of short and constant daylight, with no increase in intensity of light,

can slow down the development of photorefractoriness and consequently cause a longer duration of production with significant higher egg number and increased luteinizing hormone level.

Nutrition

Both the Israeli and the U.S.A. teams obtained similar optimal protein requirements of 18-20% protein for the young growing goslings (0-3 weeks). However, in a later age (3-7 weeks) the Israeli team estimated lower protein needs than the U.S.A. team.

Holding diet of 12% protein was adequate for prelaying geese. These results were obtained by the U.S.A. team and confirmed by the Israeli team.

The Israeli team has shown that the laying goose can regulate its protein consumption when exposed to split diets. At a high level of production (4 eggs per week) the diet consumed contained about 18% protein, but when egg production was decreased the consumption of protein level dropped to 13% only. This is in accordance with the results obtained by the U.S.A. team showing a positive response to increased dietary protein level during the laying season.

The above results of both the Israeli and U.S.A. teams suggest better food utilization/production through improved rations.

G. EVALUATION OF THE RESEARCH ACHIEVEMENTS WITH RESPECT TO THE
ORIGINAL RESEARCH PROPOSAL

Comparing the original objectives (see Section D) with the research achievements is as follows:

1. Suitable strains and crosses of male and female lines were chosen after tests' evaluation. Thereafter, a goose breeding program has been carried out (including progeny tests). Genetic gains after 4 generations of selection were 13 eggs and 145 g of crammed liver weight, which means about 25% genetic gains (Israel).
2. Genetic and phenotypic parameters were analyzed for all traits involved. Results indicate relatively high heritability estimates for the important economic traits and low correlation coefficients between traits, with relatively high expected gains (Israel).
- 3 & 4. Investigation of requirements for protein and energy were carried out (U.S.A. and Israel) for growing cramming, prelaying and laying periods.
 - a. Protein diets of 18-20% with 3000-3010 Kcal/kg resulted in the greatest growth gains to 7 weeks of age at which time the geese have reached 85% of their adult size (U.S.A.).
 - b. Sulfur amino acids requirements of the growing gosling were found to be: 2, 1.6, 1.2; and lysin requirements are 3.7, 2, 1.8 g/Mcal ME for the ages 0-2, 2-4 and 4-7 weeks, respectively (Israel).
 - c. Pelletted diet vs. mash during the growing period improved the food to gain ratio by 6% (Israel).

- d. Addition of ground wheat straw (7%) to the diet of the growing gosling improved feed utilization and fatty liver weight. These favourable effects were not due only to dietary fiber, since increasing dietary fiber concentration by using barley and wheat bran did not improve food utilization and fatty liver weight after cramming (Israel).
- e. Quantitative food restriction during the holding period prior to cramming, was found to be more efficient than qualitative restriction obtained by feeding corn: sorghum grains supplemented with minerals and vitamins. It was found that the minimal body weight at the start of cramming should be about 4 kg (Israel).
- f. Adding various fats to the forced fed diet can increase crammed liver weight by about 10% (Israel).
- g. A 12% protein prelaying holding diet was found to be adequate (U.S.A., Israel).
- h. Breeder ration of 15% protein resulted in the greatest number of eggs (U.S.A.).
- i. When exposed to split diets: high energy and high protein, or grower and layer diets, the laying geese were able to regulate their intake of nutrients according to egg production. On split diets, egg production was improved and the geese were able to maintain a high body weight (Israel).

5. Several light regimes and methods for light restriction were studied.
 - a. It was established that geese are refractory to light and therefore the light regime should be short and constant (10 hours (U.S.A.) and 13 hours (Israel)) in complete confinement as well as conventional open houses (U.S.A., Israel). This system of short and constant light was advantageous in egg production over the 16 hours constant long daylight, or increasing daylight regimes up to 17 hours daylight (U.S.A., Israel). It was shown that luteinizing hormone levels were higher for geese kept under the short 10 hours daylight, as compared to the 16 hours daylight regime (U.S.A.).
 - b. Light restriction and forced molt were employed for shifting the seasonal egg production to late summer (Israel).
6. Supplementation of artificial light from various sources at two intensity levels were studied. Incandescent tungsten light, commonly used, tended to be inferior, by about 20% in egg production, to fluorescent light sources. Intensity level of 20 lux resulted in high egg production as compared to 50 lux, probably by slowing down the development of photorefractoriness (Israel).
7. Cages were developed for geese breeders. Geese housed in cages performed poorly, their rate of egg and gosling production being less than half of that expected of geese housed in individual floor pens (Israel).
8. Techniques were developed for artificial insemination of geese (Israel).

Additional objectives:

1. Genetic-economic evaluation of all traits involved either in goose broiler, or in a goose liver enterprise were carried out. The relative genetic-economic value of all traits involved were calculated. This is important for evaluating the cost/benefit ratio for each trait involved (Israel).
2. The effect of daylength on the duration of egg production was studied, see section 5.
3. Intermittent lighting during the growing period did not have any advantage over "natural" daylight, or 16 hours daylight for growth to 7 weeks of age (U.S.A.).

H. BENEFIT TO AGRICULTURE

The goose industry was considered as being in a very primitive and prescientific state, without the benefit of proper research in breeding, nutrition and management (housing, lighting, etc.).

In the absence of breeding and multiplier farms, the renewal of replacements was done, at least in Israel, with geese taken at random from any flock available, without methodical selection.

At the end of this project the benefits are as follows:

1. The establishment of a research station as well as breeding and multiplier farms.
2. The development of suitable strains and crosses of male and female lines.
3. Constructing an efficient breeding plan, which resulted, so far, in a genetic improvement of about 25% in egg production and liver yield in strains available to the farmers.
4. Creating experimental data and nutritional basis for improved food efficiency, by:
 - a. establishing requirements for protein, essential amino acids and energy;
 - b. use of feed restriction for growing and prelaying periods;
 - c. use of pellets for the growing period;
 - d. adding ground straw during the precramming period and fat to forced-fed diets can increase liver weight by about 6%-10%.
 - e. possible use of split diets of high energy and protein for laying geese.
5. Development of practical techniques for semen collection from ganders and insemination of laying geese.

6. The possible use, on a commercial scale, of housing laying geese in individual floor pens, rather than keeping them in flocks, with a potential increase in egg production up to 83%.
7. It was found that geese are refractory to light. Providing geese with a constant daylight (10-13 hours), rather than a 16-17 hour daylight regime commonly used, greatly increased egg production and luteinizing hormone level.
8. Developing systems of light restriction and force-molting for shifting egg production to later summer. Thus, making eggs available in a season where there is a shortage in production.
9. The change from incandescent tungsten light source to fluorescent light, or from 50 lux light intensity to 20 lux, may increase egg production by about 20%.
10. Providing basic knowledge for geese in: genetics, nutrition, photoperiodism and certain managerial aspects.

The information from this project if applied immediately would result in improved efficiency of growth and especially reproduction and its worth would be several million dollars to the goose industry. Most importantly, this information has the potential for making the goose industry more competitive thereby capturing a greater share of the meat protein market. Obviously these efficiencies will be shared world wide. THE BENEFIT FOR THE GOOSE LIVER ENTERPRISE IS EVEN GREATER.

I. LIST OF PUBLICATIONS

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