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# RESPONSE OF JAPANESE QUAIL TO DIFFERENT FORCE-RESTING PROCEDURES: 2- SOME PHYSIOLOGICAL ASPECTS OF QUAILS FORCE-RESTED BY EXCESSIVE DIETARY Zn AND/OR DIETARY Ca DEFICIENCY AS COMPARED TO SEVERE QUANTITATIVE FEED RESTRICTION REGIMEN

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**Abstract:** *Two experiments were carried out to investigate the different responses of Japanese quails at the end of their egg laying season (aging about 32 wk and rate of laying about 33%) to quantitative or qualitative dietary procedures of forced rest. In the first procedure (experiment 1) different levels of dietary zinc and calcium were applied using six treatment groups. In the first treatment (HZn-HCa) birds were offered diets with high zinc level (20000 ppm, as zinc sulphate heptahydrate) and high calcium level (3.79%). Birds of the second treatment (HZn-LCa) received diets with high zinc (20000 ppm) and low calcium level (0.23%). Diet of the 3rd (LZn-HCa) and 4th (LZn-LCa) groups contained 2800 ppm zinc accompanied by 3.79% and 0.23% calcium respectively. In the 5th treatment (LCa) the diet contained no supplemental zinc but low calcium (0.23). The 6th group served as control and were fed on a diet containing the recommended levels of zinc and calcium according to NRC (1994). This experiment lasted for 13 wk. As for the second procedure (experiment 2) forced rest was induced using the fasting regimen described by Yashimura et al. (1997). Feed and water were withdrawn for three days then birds were provided with water on the 4th day of treatment and thereafter. Gradual feeding was started four days after the cessation of egg lay. Results obtained showed that the different qualitative feed restriction treatments applied in the first experiment lead to;*

*a- Sharp decrease in plasma levels of estrogen and testosterone after four weeks of treatment.*

*b- Significant (P<0.05) decrease in plasma triglycerides TG level which seemed to be parallel to rate of laying.*

*c- Marked ovarian atrophy, where ovarian mass was sharply and significantly reduced when hens were given diets containing 20000 ppm*

*Zn irrespect of the accompanying Ca level. The sharp decrease in ovarian mass was mainly due to the marked atrophy in follicular size and the disappearance of almost all of the yellow follicles.*

*d- The morphological features of the female genital tract followed the same trend observed with the ovarian measurements.*

*e- The high Zn level caused a marked atrophy of the testis.*

*The quantitative feed restriction regimen applied to induce the forced rest seemed to be more effective than those used in the qualitative feed restriction procedure. In general, birds responded nearly in the same manner, but in case of the fasting method the response was quicker and more potent. Moreover, birds started the second cycle about 3 weeks earlier and showed better persistency of egg production.*

*In conclusion, in the light of the results of the present study the fasting regimen could be recommended for inducing rest in Japanese Quails rather than the other dietary treatments.*

## INTRODUCTION

The process of moulting and the subsequent recovery from the moult appear to be a complex physiological mechanism involving endocrine systems, reproductive tissue structure and function, lymphoid structure, and immune function (Berry, 2003). A general increase in reproductive performance results from the rejuvenation effect. This rejuvenation may be associated with an increased tissue sensitivity or efficiency and reorganization of metabolic processes (Brake and Thaxton, 1979 and Park *et al.*, 2004). In addition, the loss of adipose tissue may be associated with the overall increase in performance (Brake and Thaxton, 1979 and Park *et al.*, 2004). However, both the regression and redevelopment of organs and tissues are related to the increased reproductive performance post-moult (Park *et al.*, 2004). The decrease in body weight of hens by feed withdrawal is directly related to decreased muscle, adipose tissue, liver and the involution of reproductive organs (Brake and Thaxton, 1979; Berry and Brake, 1985 and Park *et al.*, 2004). Approximately 25% of the body weight loss is connected to the decrease in liver weight and involution of the reproductive organs (Brake and Thaxton, 1979 and Park *et al.,* 2004).

Hoshino *et al.* (1988) studied changes in plasma thyroid hormones, lutenizing hormone (LH), estradoil (E2), progesterone and cotricosterone of laying hens during a force moult induced by feed deprivation. They stated that corticosterone increased at the onset of moult, peaked at maximum moult and returned to pre-moult levels. Lutenizing hormone, estrogen and progesterone declined during the moult. The decrease was coincided with

cessation of egg production; thyroxin (T4), triiodothyronine (T3) and reverse triiodothyronine (rT3) were increased during the moult.

The present study is an attempt to characterize the important aspects of some physiological and morphological events which occur in the reproductive organs and blood constituents of Japanese quails during and after the force resting period, when induced either through different levels of zinc and calcium or via applying a fasting regimen.

## MATERIALS AND METHODS

Two experiments were carried out to investigate the response of Japanese quails at the age of 32 wk to forced rest through feeding birds on high dietary zinc, low dietary calcium or different combinations between the two nutrients (Experiment 1) or via applying the fasting regimen suggested by Yashimura *et al.* (1997) (Experiment 2). Number of birds and the experimental design of the first experiment is presented in table (1), while those of the second experiment is shown in table (2). (Described in El-Habbak *et al.,* 2005). Experimental procedure described in El-Habbak *et al.* (2005).

**Blood analysis:**

Fifteen birds (5 males and 10 females) from each treatment in experiment one and nine birds (3 males and 6 females) from each treatment in experiment two were chosen randomly at the end of treatments and the end of the experimental period. Birds were sacrificed, bled individually into a sterile vial containing anticoagulant (heparin), centrifuged at 4000 rpm for 10 minutes, plasma separated and stored in deep freezer at (-20oC) until the biochemical analysis.

In experiment one, plasma estrogen ($E_2$) and testosterone were measured by radioimmunoassay as described by Webb *et al.* (1985). Plasma zinc and total calcium concentrations were determined by flame atomic absorption spectrophotetry. Triglyceride concentration was estimated as an indicator of very low density lipoprotein (VLDL) meanwhile plasma zinc ion concentration was measured as an indicator of vitellogenin as reported by Mitchell and Carlisle, (1991).

In experiment two, plasma oestrogen and testosterone were measured by radioimmunoassay as described by Webb *et al.* (1985). Plasma

T3 (Triiodothyromine) and T4 (Thyroxine) concentration were determined by radioimmunoassay as described by May (1978).

**Morphological studies:**

After sacrificing the reproductive organs in males and females were investigated as follows:

1- Testes were immediately dissected and carefully trimmed, then the epididymal region was separated and the length, breadth and thickness of each testis were measured to the nearest 100 microns. To make it easy for comparing the testes size in the different groups, the product of the three dimensions (length x breadth x thickness) was calculated and noted as testicular volume index (TVI), (El-Habbak and Radwan, 1987).

2- The oviduct was immediately dissected and carefully trimmed, than the total length of the oviduct and that of each part of it was measured, also the circumference of each part was measured.

3- Regarding the ovary, a pilot experiment was carried with a group of 40 quail hens, which were slaughtered and the ovaries were removed, then the diameters of all visible follicles were measured and classified into four main categories according to their diameters. Thus they included large yellow follicles (LYF, greater than 10 mm), small yellow follicles (SYF, between 5 and 10 mm), large white follicles (LWF, between 1 and 5 mm) and small white follicles (SWF, smaller than 1 mm).

As for ovary samples of the main experiments, follicles were measured with calipers and those > 5 mm diameter without signs of atresia were counted and recorded as committed follicles. Follicles characterized by being filled with green and black fluid were also counted and recorded as atretic, follicular atresia was determined by the appearance as described by Palmer and Babr, (1992). Also, the residual ovary (stroma) was weighed. The counted visible follicles were divided into the 4 classes of the pilot experiment.

**Statistical analysis:**

Data were statistically analyzed using the general linear models procedure “GLM” of the SAS program (1985). Differences between treatments were tested using Duncan’s Multiple Range Test (1955).

## RESULTS

### First: Response of quails to excessive dietary Zn and/or Ca deficiency:

***Plasma estrogen and testosterone hormones:***

As shown in Table (1), plasma levels of estrogen sharply decreased after four weeks of receiving the experimental diets. The decrease in estrogen level seemed to be directly correlated mainly with Zn level.

Estrogen level in the first group (HZn-HCa) reached about 17.4% of control level, while in the second group (HZn-LCa) it reached only about 14.6%.

The use of the lower level of Zn (2800 ppm) made the decrease in plasma estrogen level slightly less severe where it reached about 27.1%, 25.2%, from the control in the third and fourth groups, respectively. The lowest effect of plasma estrogen was observed in group five which reached 58.1% of control record.

At the end of the recovery period, plasma levels of estrogen in the different Zn-treated groups underwent great increases a matter which is logic and comes in agreement with the great increase in egg production obtained in these groups.

The same conclusion is also true for group 5 which received the low dietary Ca level only and showed the least level of egg production among the five treated groups.

Results of plasma testosterone levels in males (Table 1) showed exactly the same trend obtained with estrogen levels in females. The only difference is that the decrease in testosterone level due to forced rest treatments were slightly less than that obtained with estrogen. When expressed as percentage of control value, it reached 26.4%, 18.6%, 52.4%, 45.0% and 77.3% in the five treated groups, consequently.

After 8 weeks of recovery, testosterone level in all groups returned to its normal values suggesting that males restored their normal sexual activity.

**Table (1): Least square means ± S.E for E2 and Testosterone hormones during and after forced rest (experiment1).**

| Experimental group | At the end of forced rest treatment (28 day) | |
|---|---|---|
| | **E2** (pg/ml) | **Testosterone** (ng/ml) |
| HZn-HCa | 6.11 ± 0.17 $^{e}$ | 0.71 ± 0.10 $^{d}$ |
| HZn-LCa | 5.13 ± 0.17 $^{f}$ | 0.50 ± 0.10 $^{d}$ |
| LZn-HCa | 9.53 ± 0.17 $^{c}$ | 1.41 ± 0.10 $^{c}$ |
| LZn-LCa | 8.87 ± 0.17 $^{d}$ | 1.21 ± 0.10 $^{c}$ |
| LCa | 20.43 ± 0.17 $^{b}$ | 2.08 ± 0.10 $^{b}$ |
| Control | 35.16 ± 0.17 $^{a}$ | 2.69 ± 0.10 $^{a}$ |
| Significance | *** | *** |
| **Experimental group** | **At the beak of the recovery (84 day)** | |
| | **E2** (pg/ml) | **Testosterone** (ng/ml) |
| HZn-HCa | 46.16 ± 1.05 $^{a}$ | 2.90 ± 0.19 |
| HZn-LCa | 42.62 ± 1.05 $^{b}$ | 3.01 ± 0.19 |
| LZn-HCa | 36.80 ± 1.05 $^{c}$ | 2.79 ± 0.19 |
| LZn-LCa | 35.20 ± 1.05 $^{cd}$ | 2.66 ± 0.19 |
| LCa | 32.38 ± 1.05 $^{d}$ | 2.53 ± 0.19 |
| Control | 33.71 ± 1.05 $^{cd}$ | 2.48 ± 0.19 |
| Significance | *** | N.S |

N.S = non-significant.
*** = Significant at 0.1% of probability.
a, b, … f for each period, means within column having different letters are significantly different at $P<0.01$.

***Plasma levels of zinc, calcium and triglyceride:***

Plasma levels of zinc (Zn), calcium (Ca) and triglyceride (TG) at the end of the forced rest treatment period and the recovery period are presented in Table (2).

Plasma TG level was taken in our present study as indirect estimate of its VLDL content, and the latter is known for its relation with the activity of both the liver and ovary during egg yolk formation. Therefor it was not strange to fined that the results of plasma TG were in complete accordance with those of egg production and plasma estrogen level.

Statistical analysis indicated that plasma TG was significantly decreased due to the different forced rest treatments applied. Plasma TG in the treated groups reached about 74%, 61%, 85%, 68.6% and 81% of the control level in the five experimental groups, consequently.

By the end of the recovery period, plasma TG level significantly increased nearly parallel to the results of egg production (as mentioned in El-Habbak *et al*., 2005). Plasma TG level as percentage of control reached 134.9%, 130.3%, 100.6%, 102%, and 94% in the five groups, consequently.

As for plasma Ca level, results obtained indicated that during the forced rest treatment period, plasma Ca level was directly correlated with dietary Ca level. In groups fed diets containing 0.23% Ca, plasma Ca level was about 33% to 36% of their corresponding partners receiving 3.79% dietary Ca. When plasma Ca values of the group given 0.23% Ca (group 5) was compared with that for control birds receiving the basal diet (2.57% Ca) it represented only about 53.6% of it.

After returning to the normal basal diet, plasma Ca levels in the different groups were more or less equal.

As observed with the results of plasma Ca level, the same conclusion was exactly true for plasma Zn content. It was found to be directly correlated with dietary Zn levels applied during the forced rest period.

After returning to the normal basal diet, plasma Zn level in the different groups was nearly equal.

***Reproductive organs:***

**The ovary:**

Data presented in Tables (3 and 4) show changes in ovarian weight and its content of various types of follicles. It is clearly shown that the ovary underwent a marked atrophy due to the forced rest treatments applied. Ovarian mass was sharply and significantly reduced ($P > 0.001$) when hens were given diets containing 20000 ppm Zn irrespect of the accompanying Ca level (groups 1 and 2). Ovarian relative weight in these groups did not reach one tenth of that for control.

**Table (2): Least square means ± S.E for plasma level of calcium (Ca), zinc (Zn) and triglycerides (TG) during and after forced rest (experiment1).**

| Experimental group | At the end of forced rest treatment (28 day) | | |
|---|---|---|---|
| | **TG** (mg%) | **Ca** (mg/dl) | **Zn** ( ppm) |
| HZn-HCa | 46.67 ± 1.27 $^{c}$ | 31.09 ± 0.17 $^{ab}$ | 18.98 ± 0.10 $^{a}$ |
| HZn-LCa | 38.60 ± 1.27 $^{d}$ | 10.23 ± 0.17 $^{c}$ | 20.42 ± 0.10 $^{a}$ |
| LZn-HCa | 53.66 ± 1.27 $^{b}$ | 35.00 ± 0.17 $^{a}$ | 5.37 ± 0.10 $^{b}$ |
| LZn-LCa | 43.32 ± 1.27 $^{c}$ | 12.61 ± 0.17 $^{c}$ | 5.71 ± 0.10 $^{b}$ |
| LCa | 51.13 ± 1.27 $^{b}$ | 15.00 ± 0.17 $^{c}$ | 1.62 ± 0.10 $^{c}$ |
| Control | 63.14 ± 1.27 $^{a}$ | 28.01 ± 0.17 $^{b}$ | 1.61 ± 0.10 $^{c}$ |
| Significance | *** | *** | *** |
| **Experimental group** | **At the beak of the recovery (84 day)** | | |
| | **TG** (mg%) | **Ca** (mg/dl) | **Zn** ( ppm) |
| HZn-HCa | 89.18 ± 1.42 $^{a}$ | 28.44 ± 0.22 | 1.85 ± 0.03 |
| HZn-LCa | 86.17 ± 1.36 $^{a}$ | 29.13 ± 0.21 | 1.93 ± 0.03 |
| LZn-HCa | 66.53 ± 1.14 $^{b}$ | 29.70 ± 0.17 | 1.59 ± 0.02 |
| LZn-LCa | 67.44 ± 1.17 $^{b}$ | 28.25 ± 0.18 | 1.64 ± 0.02 |
| LCa | 62.13 ±1.18 $^{c}$ | 27.93 ± 0.18 | 1.65 ± 0.02 |
| Control | 66.12 ± 1.14 $^{b}$ | 29.00 ± 0.17 | 1.59 ± 0.02 |
| Significance | *** | N.S | N.S |

* = Significant at 5% of probability.

*** = Significant at 0.1% of probability.

NS = non-significant.

a, b, …d for each period, means within column having different letters are significantly different at P<0.01.

**Table (3): Least square means ± S.E for ovary weight relative to body weight and follicles number (x) during and after forced rest (experiment1).**

| Experimental group | At the end of forced rest treatment (28 day) | | | | |
|---|---|---|---|---|---|
| | Ovary weight (%) | Follicle Diameter (mm) | | | |
| | | x < 1.0 mm | 1.0 < x <5.0 mm | 5.0 < x<10.0 mm | X > 10.0 mm |
| HZn-HCa | 0.37 ± 0.36 $^{c}$ | 53.10 ± 1.91 | 18.00 ± 1.42 $^{c}$ | 0.00 $^{c}$ | 0.00 $^{c}$ |
| HZn-LCa | 0.35 ± 0.36 $^{c}$ | 51.30 ± 1.91 | 17.60 ± 1.42 $^{c}$ | 0.00 $^{c}$ | 0.00 $^{c}$ |
| LZn-HCa | 3.60 ± 0.36 $^{ab}$ | 51.00 ± 1.91 | 21.80 ± 1.42 $^{cb}$ | 1.20 ± 0.2 $^{b}$ | 0.60 ± 0.14 $^{b}$ |
| LZn-LCa | 2.94 ± 0.36 $^{b}$ | 51.90 ± 1.91 | 23.60 ± 1.42 $^{b}$ | 1.10 ±0.21 $^{b}$ | 0.50 ± 0.14 $^{b}$ |
| LCa | 2.81 ± 0.36 $^{b}$ | 50.60 ± 1.91 | 23.90 ± 1.42 $^{b}$ | 1.50 ± 0.21 $^{b}$ | 0.70 ± 0.14 $^{b}$ |
| Control | 4.11 ± 0.36 $^{a}$ | 52.30 ± 1.91 | 31.30 ± 1.42 $^{a}$ | 2.20 ± 0.21 $^{a}$ | 2.00 ± 0.14 $^{a}$ |
| Significance | *** | N.S | *** | *** | *** |
| **Experimental group** | **At the beak of the recovery (84 day)** | | | | |
| | **Ovary weight** (%) | **Follicle Diameter** (mm) | | | |
| | | x < 1.0 mm | 1.0 < x <5.0 mm | 5.0 < x<10.0 mm | X > 10.0 mm |
| HZn-HCa | 5.36 ± 0.12 $^{a}$ | 49.43 ± 1.60 | 36.43 ± 1.01 $^{a}$ | 2.86 ±0.26 $^{a}$ | 4.00 ± 0.29 $^{a}$ |
| HZn-LCa | 5.56 ± 0.11 $^{a}$ | 51.13 ± 1.49 | 36.50 ± 0.95 $^{a}$ | 2.75 ± 0.24 $^{ab}$ | 4.13 ± 0.27 $^{a}$ |
| LZn-HCa | 4.13 ± 0.10 $^{b}$ | 50.64 ± 1.27 | 29.09 ± 0.81 $^{b}$ | 2.09 ± 0.20 $^{bc}$ | 2.27 ± 0.23 $^{b}$ |
| LZn-LCa | 3.69 ± 0.10 $^{c}$ | 50.70 ± 1.33 | 29.70 ± 0.85 $^{b}$ | 2.00 ± 0.21 $^{c}$ | 2.00 ± 0.21 $^{b}$ |
| LCa | 3.95 ± 0.10 $^{cb}$ | 50.36 ± 1.27 | 30.36 ± 0.81 $^{b}$ | 2.18 ± 0.20 $^{bc}$ | 2.18 ± 0.23 $^{b}$ |
| Control | 3.83 ± 0.10 $^{cb}$ | 52.64 ± 1.27 | 29.18 ± 0.8 $^{b}$ | 2.09 ± 0.20 $^{bc}$ | 2.0 ± 0.23 $^{b}$ |
| Significance | *** | N.S | *** | * | *** |

N.S = non-significant.

* = Significant at 5% of probability.

*** = Significant at 0.1% of probability.

a, b, …c for each period, means within column having different letters are significantly different at P<0.01.

**Table (4): Least square means ± S.E for committed follicles, atretic follicles number and stroma weight during and after forced rest (experiment 1).**

| Experimental group | At the end of forced rest treatment (28 day) | | |
|---|---|---|---|
| | Committed Follicles ( >5 mm) (no.) | Atretic Follicles (no.) | Stroma Weight ( g.) |
| HZn-HCa | 0.00 $^{c}$ | 2.20 ± 0.21 $^{b}$ | 0.17 ± 0.01 $^{d}$ |
| HZn-LCa | 0.00 $^{c}$ | 3.00 ± 0.21 $^{a}$ | 0.15 ± 0.01 $^{d}$ |
| LZn-HCa | 1.80 ± 0.22 $^{b}$ | 0.80 ± 0.21 $^{cd}$ | 0.30 ± 0.01 $^{b}$ |
| LZn-LCa | 1.60 ± 0.22 $^{b}$ | 1.20 ± 0.21 $^{c}$ | 0.26 ± 0.01 $^{b}$ |
| LCa | 2.20 ± 0.22 $^{b}$ | 0.50 ± 0.21 $^{d}$ | 0.22 ± 0.01 $^{c}$ |
| Control | 4.20 ± 0.22 $^{a}$ | 0.20 ± 0.21 $^{d}$ | 0.40 ± 0.01 $^{a}$ |
| Significance | *** | *** | *** |
| **Experimental group** | **At the beak of the recovery (84 day)** | | |
| | **Committed Follicles ( >5 mm) (no.)** | **Atretic Follicles (no.)** | **Stroma Weight ( g.)** |
| HZn-HCa | 6.86 ± 0.36 $^{a}$ | 0.29 ± 0.15 | 0.43 ± 0.02 $^{a}$ |
| HZn-LCa | 6.88 ± 0.34 $^{a}$ | 0.25± 0.14 | 0.45 ± 0.01 $^{a}$ |
| LZn-HCa | 4.36 ± 0.29 $^{b}$ | 0.18 ± 0.12 | 0.39 ± 0.01 $^{b}$ |
| LZn-LCa | 4.00 ± 0.30 $^{b}$ | 0.20 ± 0.13 | 0.37 ± 0.01 $^{b}$ |
| LCa | 4.36 ± 0.29 $^{b}$ | 0.19 ± 0.12 | 0.31 ± 0.01 $^{c}$ |
| Control | 4.09 ± 0.29 $^{b}$ | 0.18 ± 0.12 | 0.28 ± 0.01 $^{c}$ |
| Significance | *** | N.S | *** |

N.S = non-significant.
*** = Significant at 0.1% of probability.
a, b, c, d for each period, means within column having different letters are significantly different at $P<0.01$.

With the lower level of Zn (2800 ppm, groups 3 and 4) the effect was less severe. Nearly the same effect was noticed when reduced dietary Ca was the only tool for inducing forced rest (group 5).

It seems that the sharp decrease in ovarian mass was mainly due to the marked atrophy in follicular size and the disappearance of almost all of the yellow follicles. Morphological examination of the ovaries of treated birds after four weeks of receiving the experimental diets proved that in HZn-HCa and HZn-LCa groups, ovaries did not contain any follicles with diameters greater than 5 mm. At the same time, the number of follicles with 1-5 mm diameter was reduced to less than 60 % of control record.

With the lower Zn level, the number of follicles having diameter greater than 10 mm comprised only from 25-30% of control meanwhile the corresponding value for the smaller follicles (5-10 mm) was about 50%. As

for group 5 (LCa) records were slightly higher than those for groups 3 and 4 with insignificant differences.

This conclusion was more confirmed when ovaries content of committed follicles (those with diameters greater than 5 mm) and atretic follicles in the different groups were compared (Table 4). No committed follicles could be seen in ovaries of HZn- groups. The number in LZn- groups comprised 38-43% of that for control, while in LCa- group it was nearly half that for control.

Stroma weight followed the same trend observed for number of committed follicles. As for the number of atretic follicles the opposite was completely true. Their number in HZn-HCa and HZn-LCa groups reached about eleven fold and fifteen fold control record, respectively. Corresponding values for LZn-HCa, LZn-LCa and LCa groups were four fold, six fold and two and half-fold, consequently.

After eight weeks of returning to the normal basal diet female gonads exhibited significantly higher level of activity as compared with their untreated partners. At the peak of the second cycle hens in the two high zinc–groups exceeded those of the other groups with respect to all ovarian parameters studied. This coincides with the results of egg production during this period.

***The oviduct:***

Results presented in Table (5) clearly show that the morphological features of the female genital tract followed the same trend observed with the ovarian measurements. After 28 days of forced-rest treatments a sharp decrease in oviduct weight was obtained. In groups received diets with the high Zn level (group 1 & 2) the oviduct weight was as low as 13-14% of that for control hens.

The corresponding values in low Zn (group 3 & 4) and low Ca groups (group 5) ranged between 60-70%. At the end of the recovery period during which birds returned to the normal basal diet, oviduct weight in high Zn level groups increased more than tenfold it's value at the end of the forced-rest treatment. In LZn-HCa, LZn-LCa and LCa groups a slight increase in their genital tracts weight ranging between 24-45% of their post-treatment values was noticed. A corresponding decrease of about 19% was observed in control group.

As for the oviduct length it exhibited identically the same changes seen with weight records. A sharp decrease occurred in total oviduct length due to forced-rest treatments where it reached about 48%, 43%, 77%, 63% and 71% of that for control in HZn-HCa, HZn-LCa, LZn-HCa, LZn-LCa and LCa groups, respectively.

When the length of each region of the oviduct was statistically analyzed separately it was observed that the change in the five regions nearly followed the trend observed in case of the total length of the tract which mean that the response was nearly equal in the five regions.

At the end of the recovery period both the total and the segmental lengths of the genital tract of treated hens significantly increased and exceeded the corresponding values of control birds. The total length of the oviduct after 8 weeks of returning to the basal diet increased to about 267%, 291%, 124% , 160% and 138% of the post-treatment value in HZn-HCa, HZn-LCa, LZn-HCa, LZn-LCa and LCa groups, consequently.

**The Testes:**

Results regarding testes weight and dimensions as influenced by the different forced rest treatments applied are presented in Table (6). Statistical analysis proved that the only significant effect was due to the high zinc level (20000 ppm) where a reduction in testes weight reaching about 35% to 45% was observed in HZn-HCa and HZn-LCa.

**Table (5): Least square means ± S.E for oviduct length (cm). (Experiment 1)**

| Experimental group | Oviduct weight (%) | At the end of forced rest treatment (28 day) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Oviduct Length (cm) | | | | | |
| | | Total length | Funnel | Magnum | Isthmus | Uterus | Vagina |
| HZn-HCa | 0.75 ± 0.32 $^{e}$ | 7.31 ± 0.16 $^{e}$ | 1.51 ± 0.07 $^{d}$ | 3.02 ± 0.09 $^{e}$ | 1.55 ± 0.09 $^{d}$ | 1.00 ± 0.07 $^{e}$ | 0.25 ± 0.03 $^{c}$ |
| HZn-LCa | 0.79 ± 0.32 $^{e}$ | 6.48 ± 0.16 $^{f}$ | 1.18 ± 0.07 $^{e}$ | 2.59 ± 0.09 $^{c}$ | 1.70 ± 0.09 $^{d}$ | 0.89 ± 0.07 $^{e}$ | 0.32 ± 0.03 $^{bc}$ |
| LZn-HCa | 3.92 ± 0.32 $^{b}$ | 11.6 ± 0.16 $^{b}$ | 1.87 ± 0.07 $^{c}$ | 3.76 ± 0.09 $^{c}$ | 3.21 ± 0.09 $^{b}$ | 2.11 ± 0.07 $^{c}$ | 0.41 ± 0.03 $^{a}$ |
| LZn-LCa | 3.34 ± 0.32 $^{b}$ | 9.52 ± 0.16 $^{d}$ | 1.50 ± 0.07 $^{d}$ | 2.62 ± 0.09 $^{c}$ | 3.02 ± 0.09$^{bc}$ | 2.00 ± 0.07 $^{c}$ | 0.38 ± 0.03 $^{ab}$ |
| LCa | 3.64 ± 0.32 $^{b}$ | 10.72 ± 0.16 $^{c}$ | 2.21 ± 0.07 $^{b}$ | 3.24 ± 0.09 $^{c}$ | 2.92 ± 0.09 $^{c}$ | 1.95 ± 0.07 $^{c}$ | 0.43 ± 0.03 $^{a}$ |
| Control | 5.54 ± 0.32 $^{a}$ | 15.12 ± 0.16 $^{a}$ | 2.41 ± 0.07 $^{a}$ | 5.54 ± 0.09 $^{c}$ | 4.00 ± 0.09 $^{a}$ | 2.72 ± 0.07 $^{c}$ | 0.45 ± 0.03 $^{a}$ |
| Significance | *** | *** | *** | *** | *** | *** | *** |
| **Experimental group** | **Oviduct weight (%)** | **At the beak of the recovery (84 day)** | | | | | |
| | | **Oviduct Length** (cm) | | | | | |
| | | Total length | Funnel | Magnum | Isthmus | Uterus | Vagina |
| HZn-HCa | 7.91 ± 0.09 $^{a}$ | 19.53 ± 0.17$^{a}$ | 2.60 ± 0.11 | 7.83 ± 0.12$^{a}$ | 4.51 ± 0.14$^{a}$ | 4.00 ± 0.10$^{a}$ | 0.56 ± 0.03$^{ab}$ |
| HZn-LCa | 8.02 ± 0.09 $^{a}$ | 18.88 ± 0.16$^{b}$ | 2.65 ± 0.10 | 7.15 ± 0.12$^{b}$ | 5.68 ± 0.13$^{a}$ | 3.78 ± 0.09$^{a}$ | 0.61 ± 0.03$^{a}$ |
| LZn-HCa | 4.98 ± 0.07 $^{b}$ | 14.42 ± 0.14$^{d}$ | 2.41 ± 0.09 | 4.96 ± 0.09$^{c}$ | 3.80 ± 0.11$^{b}$ | 2.92 ± 0.08$^{b}$ | 0.51 ± 0.03$^{bc}$ |
| LZn-LCa | 4.83 ± 0.08 $^{b}$ | 15.22 ± 0.14$^{c}$ | 2.50 ± 0.09 | 5.83 ± 0.10$^{c}$ | 3.81 ± 0.12$^{b}$ | 2.60 ± 0.08$^{c}$ | 0.48 ± 0.03$^{bc}$ |
| LCa | 4.50 ± 0.08 $^{c}$ | 14.80 ± 0.14$^{cd}$ | 2.44 ± 0.09 | 5.18 ± 0.10$^{de}$ | 3.95 ± 0.12$^{b}$ | 2.77 ± 0.08$^{bc}$ | 0.46 ± 0.03$^{c}$ |
| Control | 4.51 ± 0.07 $^{c}$ | 14.91 ± 0.13 $^{c}$ | 2.32± 0.09 | 5.32 ± 0.09$^{d}$ | 4.09 ± 0.11$^{b}$ | 2.66 ± 0.08$^{c}$ | 0.52 ± 0.03$^{bc}$ |
| Significance | *** | *** | N.S | *** | *** | *** | * |

N.S = non-significant.
* = Significant at 5% of probability.
*** = Significant at 0.1% of probability.
a, b, c, d for each period, means within column having different letters are significantly different at P<0.01.

**Table (6): Least square means ± S.E for testes weight relative to body weight, testicular dimensions (cm) and testis volume index (TVI). (Experiment 1)**

| Experimental group | At the end of forced rest treatment (28 day) | | | | Testis Volume index (TVI) |
|---|---|---|---|---|---|
| | Testes weight (%) | Testicular dimensions | | | |
| | | Length | Breadth | Thickness | |
| HZn-HCa | 2.23 ± 0.31 $^{b}$ | 1.16 ± 0.08 $^{c}$ | 0.85 ± 0.09 $^{b}$ | 0.64 ± 0.08 $^{b}$ | 0.63 ± 0.34 $^{b}$ |
| HZn-LCa | 1.92 ± 0.31 $^{b}$ | 1.25 ± 0.08 $^{c}$ | 0.78 ± 0.09 $^{b}$ | 0.72 ± 0.08 $^{b}$ | 0.74 ± 0.34 $^{b}$ |
| LZn-HCa | 3.62 ± 0.31 $^{a}$ | 2.43 ± 0.08 $^{b}$ | 1.34 ± 0.09 $^{a}$ | 1.09 ± 0.08 $^{a}$ | 3.53 ± 0.34 $^{a}$ |
| LZn-LCa | 3.49 ± 0.31 $^{a}$ | 2.39 ± 0.08 $^{b}$ | 1.30 ± 0.09 $^{a}$ | 1.15 ± 0.08 $^{a}$ | 3.64 ± 0.34 $^{a}$ |
| LCa | 3.16 ± 0.31 $^{a}$ | 2.51 ± 0.08 $^{ab}$ | 1.28 ± 0.09 $^{a}$ | 1.11 ± 0.08 $^{a}$ | 3.59 ± 0.34 $^{a}$ |
| Control | 3.47 ± 0.31 $^{a}$ | 2.71 ± 0.08 $^{a}$ | 1.33 ± 0.09 $^{a}$ | 1.18 ± 0.08 $^{a}$ | 4.17 ± 0.34 $^{a}$ |
| Significance | ** | *** | *** | *** | *** |

| Experimental group | At the beak of the recovery (84 day) | | | | Testis Volume index (TVI) |
|---|---|---|---|---|---|
| | Testes weight (%) | Testicular dimensions | | | |
| | | Length | Breadth | Thickness | |
| HZn-HCa | 3.06 ± 0.13 | 2.63 ± 0.13 | 1.36 ± 0.10 | 1.30 ± 0.11 | 4.67 ± 0.48 |
| HZn-LCa | 3.05 ± 0.13 | 2.54 ± 0.13 | 1.40 ± 0.10 | 1.26 ± 0.11 | 4.38 ± 0.48 |
| LZn-HCa | 3.25 ± 0.10 | 2.59 ± 0.11 | 1.35 ± 0.08 | 1.19 ± 0.09 | 4.16 ± 0.39 |
| LZn-LCa | 3.17 ± 0.10 | 2.68 ± 0.11 | 1.37 ± 0.08 | 1.24 ± 0.09 | 4.49 ± 0.39 |
| LCa | 3.21 ± 0.10 | 2.60 ± 0.11 | 1.33 ± 0.08 | 1.30 ± 0.09 | 4.48 ± 0.39 |
| Control | 3.21 ± 0.10 | 2.65 ± 0.11 | 1.37 ± 0.08 | 1.22 ± 0.09 | 4.53 ± 0.39 |
| Significance | N.S | N.S | N.S | N.S | N.S |

N.S = non-significant.
*** = Significant at 0.1% of probability.
** = Significant at 1% of probability.
a, b, C for each period, means within column having different letters are significantly different at P<0.01.

The other three treatments showed no significant effect on the testes. The same trend was observed with testicular dimensions. At the end of the recover period (eight weeks), testes restored their normal volume and did not significantly differ from the control group.

**Second: Response of quails to fasting regime:**

***Hormonal assays:***

As shown in Table (7) a sharp decrease in plasma estrogen and testosterone was obtained due to fasting treatment. At the end of the forced rest treatment plasma estrogen and testosterone levels in the treated group were only about 14.4 % and 36.2 % of control levels, respectively.

As bird returned to the normal ad-libitum feeding regimen, the level of the two hormones increased gradually. By day 17 plasma estrogen of the fasted group reached about 40.8 % of control, meanwhile the corresponding value of testosterone was about 49.4 %. During the following weeks females of the treated group exhibited a higher level of plasma estrogen reaching about 135 % of control level. Results presented in Table (7) show that plasma T3 and T4 were not significantly affected due to the fasting regimen applied.

**Reproductive organs:**

***The ovary:***

Results regarding the response of the ovary to fasting regimen are presented in Tables (8 and 9). It is clearly seen that both of the ovarian weight and the number of the ovarian follicles were significantly reduced. Moreover, the ovaries of treated hens contained no follicles with diameters greater than 5 mm. After 5-days of returning to the normal dietary regimen ovarian weight slightly increased mainly due to the increase in the number of follicles with the diameter of one millimeter and less than five millimeters. However, no follicles greater than five millimeters was seen.

By time a rapid growth of the ovary was observed leading to the high rate of egg production mentioned previously. A marked increase was observed in the numbers of large yellow follicles with diameters greater than ten millimeters.

This observation was more confirmed though the data presented in Tables (8 and 9) where at the end of forced rest treatment ovaries of treated

birds contained no committed follicles, but greater number of atretic follicles (about tenfold the control record). Besides, stroma weight was sharply decreased and reached about half the value of control birds.

**Table (7): Least square means ± S.E for plasma T3, T4, E2 and testosterone hormones level. (experiment 2).**

| Experimental group | T3 (ng/ml) | T4 (ng/ml) | E2 (pg/ml) | Testosterone (ng/ml) |
|---|---|---|---|---|
| **At the end of forced rest treatment (7 day):** | | | | |
| Fast. | 1.89±0.05 | 6.40±0.21 | 5.52±0.09[b] | 0.92±0.05[b] |
| Cont. | 1.96±0.05 | 6.92±0.21 | 38.32±0.09[a] | 2.54±0.05[a] |
| Sig. | NS | NS | *** | *** |
| **After 5 day of the recovery (17 day):** | | | | |
| Fast. | 1.84±0.06 | 7.00±0.02 | 15.12±0.14[b] | 1.19±0.06[b] |
| Cont. | 1.99±0.06 | 6.95±0.02 | 37.02±0.14[a] | 2.41±0.06[a] |
| Sig. | NS | NS | *** | *** |
| **At the beak of the recovery (63 day):** | | | | |
| Fast. | 2.00±0.07 | 6.81±0.02 | 53.12±0.16[a] | 2.53±0.03 |
| Cont. | 2.03±0.07 | 6.78±0.02 | 39.40±0.16[b] | 2.49±0.03 |
| Sig. | NS | NS | *** | NS |

N.S = non-significant.
*** = Significant at 0.1% of probability.
a, b … for each period, means within column having different letters are significantly different at P<0.01.

**Table (8): Least square means ± S.E for ovary weight relative to body weight and follicles number. (experiment 2)**

| Experimental group | At the end of forced rest treatment (7 day) | | | | |
|---|---|---|---|---|---|
| | Ovary weight % | x < 1.0 mm | 1.0 < x <5.0 mm | 5.0 < x<10.0 mm | x > 10.0 mm |
| Fast. | 0.41±0.08 [b] | 40.0±1.14 [b] | 12.0±0.84 [b] | 0.0 [b] | 0.00 [b] |
| Cont. | 5.04±0.08 [a] | 48.0±1.14 [a] | 26.0±0.84 [a] | 3.00±0.18 [a] | 2.67±0.15 [a] |
| Significance | *** | ** | *** | *** | *** |
| **Experimental group** | **After 5 days of the recovery (17 day)** | | | | |
| | **Ovary weight %** | **x < 1.0 mm** | **1.0 < x < 5.0 mm** | **5.0 < x < 10.0 mm** | **x > 10.0 mm** |
| Fast. | 1.69±0.12 [b] | 47.00±1.08 | 20.0±1.24 [b] | 0.00 [b] | 0.00 [b] |
| Cont. | 4.51±0.12 [a] | 45.00±1.08 | 25.0±1.24 [a] | 2.50±0.16 [a] | 3.00±0.26 [a] |
| Significance | *** | N.S | * | *** | *** |
| **Experimental group** | **At the beak of the recovery (63 day)** | | | | |
| | **Ovary weight %** | **x < 1.0 mm** | **1.0 < x < 5.0 mm** | **5.0 < x< 10.0 mm** | **x > 10.0 mm** |
| Fast. | 5.30±0.15 [a] | 60.00±1.14 [a] | 33.0±0.73 [a] | 3.00±0.28 | 4.33±0.32 [a] |
| Cont. | 4.43±0.15 [b] | 51.33±1.14 [b] | 24.00±0.73 [b] | 2.83±0.28 | 2.67±0.32 [b] |
| Significance | ** | ** | *** | N.S | ** |

N.S = non-significant.
* = Significant at 5% of probability.
** = Significant at 1% of probability.
*** = Significant at 0.1% of probability.
a, b … for each period, means within column having different letters are significantly different at P<0.01.

**Table (9): Least square means ± S.E for committed and atretic follicles number and stroma weight. (experiment 2)**

| Experimental group | At the end of forced rest treatment (7 day) | | |
|---|---|---|---|
| | Committed Follicles ( > 5 mm) | Atretic Follicles (no) | Stroma Weight (g) |
| Fast. | 0.00 [b] | 1.67±0.19 [a] | 0.17±0.01 [b] |
| Cont. | 5.67±0.15 [a] | 0.17±0.19 [b] | 0.32±0.01 [a] |
| Significance | *** | ** | *** |
| **Experimental group** | **After 5 days of the recovery (17 day)** | | |
| | **Committed Follicles ( > 5 mm)** | **Atretic Follicles (no)** | **Stroma Weight (g)** |
| Fast. | 0.00 [b] | 1.50±0.19 [a] | 0.22±0.008 [b] |
| Cont. | 5.50±0.35 [a] | 0.17±0.19 [b] | 0.29±0.008 [a] |
| Significance | *** | ** | *** |
| **Experimental group** | **At the beak of the recovery (63 day)** | | |
| | **Committed Follicles ( > 5 mm)** | **Atretic Follicles (no)** | **Stroma Weight (g)** |
| Fast. | 7.33±0.42 [a] | 0.33±0.21 | 0.39±0.006 [a] |
| Cont. | 5.50±0.42 [b] | 0.33±0.21 | 0.35±0.006 [b] |
| Significance | ** | N.S | ** |

N.S = non-significant.
** = Significant at 1% of probability.
*** = Significant at 0.1% of probability.
a, b … for each period, means within column having different letters are significantly different at P<0.01.

A slight improvement was observed after 5 days of recovery. As age advanced the number of committed follicles and especially that of large yellow follicles of treated group was significantly increased.

**The Oviduct:**

Results obtained proved that the oviduct showed the same response observed with the ovary (Table 10). A severe atrophy was observed due to the fasting regimen applied. Moreover, the five regions of the genital tract responded with the same degree. Oviductal weight and dimensions followed the same changes observed with ovarian morphology.

**The Testes:**

Data presented in Table (11) showed the morphological changes of male gonads as affected by fasting treatment. Testicular weight and dimensions nearly followed the same trend observed with the female reproductive organs (the ovary and the oviduct).

At the end of the forced rest treatment and till the fifth day of the recovery period, the testis volume index of the treated group was only about 14.0 % of that for control birds. At the peak of the recovery period (63 day) testis volume index of treated birds exceeded that for control ones being about 116 %, but the difference was statistically insignificant.

## DISCUSSION

### Estrogen and testosterone hormones:

Results of biochemical analysis showed that plasma levels of estrogen and testosterone sharply decreased in response to the different methods applied to force quails to rest. These results are in harmony with those reported previously by Tanabe *et al.,* 1981; Attia *et al.,* 1994; and Buchanan *et al.,* 2000.

Evidence supports the hypothesis that ovulation by fasting hens terminates as a consequence of a gonadotropin deficiency. Exogenous gonadotropins induced ovulation in starving pullets (Morris and Nalbandov, 1961) and in pullets which had ceased ovulating because of calcium deficiency (Taylor *et al.,* 1962).

**Table (10): Least square means ± S.E for oviduct length (cm). (experiment 2)**

| Experimental group | Oviduct Weight | At the end of forced rest treatment (7 day) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Oviduct Length (cm) | | | | | |
| | | Total length | Funnel | Magnum | Isthmus | Uterus | Vagina |
| Fast. | 2.45 $^{b}$ | 6.10 $^{b}$ | 1.20 $^{b}$ | 2.50 $^{b}$ | 1.40 $^{b}$ | 0.80 $^{b}$ | 0.20 $^{b}$ |
| Cont. | 5.16 $^{a}$ | 14.00 $^{a}$ | 2.30 $^{a}$ | 4.80 $^{a}$ | 3.9 $^{a}$ | 2.60 $^{a}$ | 0.40 $^{a}$ |
| S.E. | 0.18 | 0.19 | 0.04 | 0.05 | 0.05 | 0.07 | 0.03 |
| Significance | *** | *** | *** | *** | *** | *** | ** |
| **Experimental group** | **Oviduct Weight** | **After 5 days of the recovery (17 day)** | | | | | |
| | | **Oviduct Length (cm)** | | | | | |
| | | Total length | Funnel | Magnum | Isthmus | Uterus | Vagina |
| Fast. | 2.45 $^{b}$ | 5.80 $^{b}$ | 1.00 $^{b}$ | 2.20 $^{b}$ | 1.50 $^{b}$ | 0.90 $^{b}$ | 0.20 $^{b}$ |
| Cont. | 5.16 $^{a}$ | 14.80 $^{a}$ | 2.10 $^{a}$ | 6.00 $^{a}$ | 3.80 $^{a}$ | 2.50 $^{a}$ | 0.47 $^{a}$ |
| S.E. | 0.18 | 0.18 | 0.05 | 0.08 | 0.12 | 0.07 | 0.03 |
| Significance | *** | *** | *** | *** | *** | *** | *** |
| **Experimental group** | **Oviduct Weight** | **At the beak of the recovery (63 day)** | | | | | |
| | | **Oviduct Length (cm)** | | | | | |
| | | Total length | Funnel | Magnum | Isthmus | Uterus | Vagina |
| Fast. | 7.12 $^{a}$ | 19.05 $^{a}$ | 2.55 $^{a}$ | 8.40 $^{a}$ | 4.00 $^{a}$ | 3.60 $^{a}$ | 0.57 $^{a}$ |
| Cont. | 5.05 $^{b}$ | 13.50 $^{b}$ | 1.80 $^{b}$ | 5.25 $^{b}$ | 3.50 $^{b}$ | 2.50 $^{b}$ | 0.40 $^{b}$ |
| S.E. | 0.14 | 0.38 | 0.09 | 0.18 | 0.08 | 0.13 | 0.05 |
| Significance | *** | *** | *** | *** | ** | *** | * |

N.S = non-significant.
** = Significant at 1% of probability.
*** = Significant at 0.1% of probability.
a, b … for each period, means within column having different letters are significantly different at $P<0.01$.

**Table (11): Least square means ± S.E for testes weight relative to body weight (%), testicular dimensions (cm) and testes volume index (TVI). (experiment 2).**

| Experimental group | At the end of forced rest treatment (7 day) | | | | |
|---|---|---|---|---|---|
| | Testes Weight (%) | Testicular dimensions | | | Testes Volume index ( TVI ) |
| | | Length | Breadth | Thickness | |
| Fast. | 2.52 [b] | 1.21 [b] | 0.73 [b] | 0.70 [b] | 0.62 [b] |
| Cont. | 3.69 [a] | 2.43 [a] | 1.41 [a] | 1.30 [a] | 4.45 [a] |
| S.E. | 0.14 | 0.04 | 0.02 | 0.06 | 0.13 |
| Significance | *** | *** | *** | ** | *** |
| **Experimental group** | **After 5 days of the recovery (17 day)** | | | | |
| | **Testes Weight (%)** | **Testicular dimensions** | | | **Testes Volume index ( TVI )** |
| | | Length | Breadth | Thickness | |
| Fast. | 2.39 [b] | 1.11 [b] | 0.80 [b] | 0.71 [b] | 0.63 [b] |
| Cont. | 3.64 [a] | 2.56 [a] | 1.39 [a] | 1.23 [a] | 4.37 [a] |
| S.E. | 0.16 | 0.05 | 0.06 | 0.02 | 0.06 |
| Significance | ** | *** | ** | *** | *** |
| **Experimental group** | **At the beak of the recovery (63 day)** | | | | |
| | **Testes Weight (%)** | **Testicular dimensions** | | | **Testes Volume index ( TVI )** |
| | | Length | Breadth | Thickness | |
| Fast. | 3.45 | 2.50 | 1.42 | 1.24 | 4.39 |
| Cont. | 3.38 | 2.61 | 1.30 | 1.11 | 3.77 |
| S.E. | 0.11 | 0.07 | 0.06 | 0.05 | 0.23 |
| Significance | N.S | N.S | N.S | N.S | N.S |

N.S = non-significant.
** = Significant at 1% of probability.
*** = Significant at 0.1% of probability.
a, b … for each period, means within column having different letters are significantly different at P<0.01.

Zinc is a well-known antagonist of calcium (Underwood, 1977) and has been suggested to interfere with calcium metabolism through its actions on calmodulin (Brewer *et al.,* 1979). So it is perhaps not surprising to find in the present study that group 2 (HZn-LCa) exhibited the most sever symptoms of Zn toxicity and calcium deficiency.

However, the exact mechanism by which an excess of Zn interferes with ovulation and egg laying remains to be determined but incorporation of high Zn levels into the diet reduces feed intake to 10-15% from the normal level. There was also a preferential Zn accumulation in the kidney (130µg/g tissue), liver (290 µg/g tissue) and especially in the pancreas (860 µg/g tissue) (McCormic and Cunningham, 1984). In the latter, Zn interfered with insulin secretion, possibly by reducing the intracellular Ca functions and the activation of calmodulin (Ghafgazi *et al.*, 1981). This results in lower

insulin secretion, subsequently increased glucose level in blood and urine, dehydration, and fat protein catabolism. Zinc also disturbed the normal deposition in bones and increased its elimination by faces and urine (Van Reen, 1953; Scott *et al.*, 1976). This may be of relevance bearing in mind the importance of $Ca^{++}$ in regulating hypothalamo-hypophyseal activity.

Johnson and Brake, (1992) indicated that the effects of Zn as inhibitor of progesterone production occur both prior and subsequent to cAMP formation. Specifically, zinc suppresses cAMP formation at a site distal to the LH receptor, and in addition blocks progesterone production presumably by interfering with steroid "substrate" availability or by noncompetitively inhibiting steroidogenic synthetic enzymes.

**Thyroid Hormones:**

The present studies revealed that plasma T3 and T4 were not significantly affected due to the fasting regimen applied. However, inhibition of induction of ovulation during the cessation of egg laying or at the beginning of the second production year, are all concerned with interactions of the same hormones upon the hypothalamo-hypophyseal-ovarian axis (Van Tienhoven, 1981). Upon this axis, interactions of other hormones are grafted, and especially thyroid hormone and prolactin are known to have antigonadotropic effects (Camper and Burke, 1977).

According to Brake *et al.* (1979), plasma T4 initially decreased upon removal of feed, but increased above control levels by the sixth day of feed withdrawal. T3 levels remained relatively constant throughout the feed withdrawal period. The initial decrease in T4 may represent a decreased output of T4 from the thyroid or an increased peripheral metabolism of the hormone associated with fasting in the sexually mature hen. The initial decrease in T4 was followed by an increase in T4, and this was found to be coincident with a loss of ovarian weight and presumably function.

Davis *et al.* (2000) claimed that an increase in circulating T4 may be probably an important physiological factor for the initiation of molting because exogenous T4 administration has been observed to cause molting in laying chickens. In addition, the post-molt period is a time of regrowth and regeneration of the reproductive tract and feather. Thus, elevated T4 may be related to the metabolic effects that are required for regrowth and regeneration.

It is worthy to say that the main reason for the contrast between our result and those obtained by other workers is due to the difference in the techniques applied for taking blood samples. In the present study blood samples were taken at the end of the fasting treatment from fifteen birds per group (fasted and control groups) and the average records were statistically compared. Due to the wide variations among birds within the same group no significant differences between groups could be proved. We think that it would have been more reliable if the comparison had been done on individual basis between pre- and post- treatment estimates.

In the current study, plasma zinc ion concentration was measured as an indicator of vitellogenin (Mitchell and Carlisle, 1991) and triglyceride (TG) concentration as an indicator of VLDL.

Results obtained revealed that plasma TG was significantly decreased due to the different forced rest treatments applied. By the end of the recovery period, plasma TG level significantly increased nearly parallel to the results of egg production.

According to Bollengir *et al.* (1998), high plasma concentrations of VLDL and vitellogenin which are egg yolk precursors reflect an elevated plasma estrogen level. Therefore, the sharp decrease in plasma TG of force rested birds coincide with the cessation of egg laying observed in these groups.

As for plasma Ca and Zn levels they were found to be directly correlated with dietary Ca and Zn levels applied during the forced rest period. Since plasma Zn level was measured as an indicator of vetellogenin its results seem to apparently contradict with the results of TG, estrogen, and egg production. However, we think that there is no place for such contradiction. According to the references, plasma Zn concentration is taken as indirect indicator for vettelogenin (Mitchell and Carlisle, 1991) and in our opinion, this relation could be true under normal diet containing the recommended levels of Zn (45 ppm). But under the extremely high level of Zn in our present study, such relation is not likely to exist as relatively huge amounts of Zn are supposed to accumulate in different tissue and organs such as liver, kidneys, and pancreas (McCormick and Cunningham, 1984; and Williams *et al.,* 1989). A matter which may cause a kind of Zn-toxicity.

**Reproductive Organs:**

The most marked results of the present study were the significant atrophy of the reproductive organs due to forced rest via high dietary Zn or water and food deprivation.

The beneficial effects, in terms of post-molt egg production and shell quality (i.e. during the second laying cycle), have been referred to as a rejuvenation. Mechanisms of action postulated for this rejuvenation include removal of excess adipose deposits and complete regression of the reproductive tract (Brake and Thaxton, 1979).

Baker *et al.* (1981) provided support for these hypotheses when they reported that uterine lipid did not decrease significantly until a 25 to 30% reduction in body weight had occurred. This was closely associated with complete, in terms of weight loss, reproductive tract regression. If, in fact, this theory reasonably accurate, then optimum post-molt egg production and shell quality should be exhibited by hens whose body weights approximated this 25 to 30% weight loss. The present study provides such evidence.

According to Tanabe *et al.* (1981), starvation causes follicular atresia in the hen, probably due to the decrease of gonadotropin secretion from the pituitary, and that starvation may reduce pituitary gonadotroph sensitivity to LH releasing hormone in the hen. This has been the generally accepted mechanism by which fasting causes hens to go out of production, i.e., the blockage has been hypothesized to be at the hypothalamic pituitary level.

Calcium deficiency was reported to cause a concomitant atrophy of ovaries and oviducts of the laying hen (Nevalainen*,* 1969). The genital atrophy is suggested to be due to the decreased gonadotrophin secretion by the anterior pituitary in the calcium deficient bird (Taylor, 1965).The oviduct atrophy was attributed to decreased sex steroid secretion caused by insufficient gonadotrophic stimulation during calcium-depletion. Our results are in agreement with Breeding *et al.,* 1992; Johnson and Brake, 1992; and Lilburn *et al.*, 1993.

The mechanism by which high dietary Zn affects reproductive organs was reported to be due, in part, to decrease feed intake (Berry and Brake, 1985). However, according to Breeding *et al.* (1992), moderate levels of Zn caused an increased rate of reproductive involution even though

this occurred without statistically different feed consumption. This suggests a specific effect of zinc aside from anorexia.

In the literature, when hens fed large amounts of zinc have been compared with fasted hens, the amount of ovary and oviduct regression has been similar or the same (Berry and Brake, 1985; McCormick and Cunningham, 1987). However, Berry and Brake (1985) reported that hens fed large amounts of zinc exhibited earlier recrudescence. This could possibly be due to different blockade sites. Because fasting appears to create a blockage at the hypothalamic-pituitary level, plasma gonadotropins are decreased (Tanabe *et al.,* 1981). Zinc-induced molting may create a blockage at the level of the ovary and plasma gonadotropins (i.e., LH) may remain elevated. Once the zinc diet is removed, the blockage is released. Because the ovarian stimulants (gonadotropins) are present, recrudescence could begin more quickly than for fasted hens.

Our results indicated that the female genital tract underwent total regression due to forced rest treatments. It is assumed that induced molting exerts its effect on egg producing functions by rejuvenation of reproductive organs, including regression and remodeling of oviducal tissues. Eroshenko and Wilson (1974) reported that during the molting period a reduction in cell size of mucosal epithelium and an involution of tubular glands occurred in the oviduct. Quantitively, Yu and Marquardt (1974) determined that oviduct weight and the number of cells in the magnum, isthmus, and shell gland decreased during oviducal regression.

In conclusion, in the light of the results of the present study the fasting regimen could be recommended for inducing rest in Japanese Quails rather than the other dietary treatments.

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## الملخص العربي

## إستجابة السمان اليابانى للطرق المختلفة للراحة الاجبارية

## 2- بعض الظواهر الفسيولوجية للسمان اليابانى المعرض للراحة الاجبارية عن طريق المحتوى العالى من الزنك او المنخفض من الكالسيوم فى العليقة او كلاهما مقارنة بطريقة التصويم

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اجريت هذه التجارب بمزرعة الدواجن التابعة لقسم انتاج الدواجن بكلية الزراعة بكفرالشيخ جامعة طنطا، واستهدفت هذه التجارب دراسة مدى امكانية دفع طيور السمان اليابانى الى الراحة الاجبارية فى نهاية موسم انتاج البيض كوسيلة لادخاله فى دورة انتاج جديدة يمكن من خلالها مضاعفة الحياة الانتاجية للقطيع ولتحقيق هذا الهدف تم دراسة طريقتين مختلفتين لاحداث الراحة الاجبارية للطيور.

**التجربة الاولى** : كانت المعاملات فيها كالاتى:

**المجموعة الاولى** : قدم للطيور عليقة تحتوى على مستوى مرتفع من الزنك مع مستوى مرتفع من الكالسيوم (20000 جزء فى المليون كبريتات زنك ، 3.79% كالسيوم).

**المجموعة الثانية**: قدم للطيور عليقة تحتوى على مستوى مرتفع من الزنك مع مستوى منخفض من الكالسيوم (20000 جزء فى المليون كبريتات زنك ، 0.23% كالسيوم).

**المجموعة الثالثة**: قدم للطيور عليقة تحتوى على مستوى منخفض من الزنك مع مستوى مرتفع من الكالسيوم (2800 جزء فى المليون كبريتات زنك ، 3.79% كالسيوم).

**المجموعة الرابعة**: قدم للطيور عليقة تحتوى على مستوى منخفض من الزنك مع مستوى منخفض من الكالسيوم (2800 جزء فى المليون كبريتات زنك ، 0.23% كالسيوم).

**المجموعة الخامسة**: قدم للطيور عليقة تحتوى على مستوى منخفض من الكالسيوم بدون اضافة الزنك (0.23% كالسيوم).

**المجموعة السادسة**: (مجموعة المقارنة): قدم للطيور عليقة تحتوى على الاحتياجات الاساسية من الزنك والكالسيوم (45 جزء فى المليون زنك ، 2.57% كالسيوم).

**التجربة الثانية** : تناولت دراسة مدى كفاءة نظام التصويم كطريقة لاحداث الراحة الاجبارية فى طيور السمان حيث قسمت الطيور الى مجموعتين :

**المجموعة الاولى** : تعرضت فيها الطيور الى منع الماء لمدة ثلاثة ايام ولمنع الغذاء لمدة سبعة ايام.

**المجموعة الثانية** : كانت مجموعة مقارنة

**ويمكن تلخيص أهم النتائج المتحصل عليها في النقاط الاتية:**

**التجربة الاولى:**

- حدث انخفاض حاد فى مستوى استروجين وتستوستيرون البلازما فى الطيور المعاملة وكان ذلك مرتبطا تماما مع مستوى الزنك فى العليقة.

- لوحظ انخفاض محتوى البلازما من الجليسريدات الثلاثية فى الطيور التى تعرضت لمعاملات الراحة الايجبارية، الا انه مع العودة الى التغذية الطبيعية وبعد ثمانية اسابيع من الدخول فى الدورة الثانية لانتاج البيض حدثت زيادة معنوية فى تركيزها بما يتماشى تمام مع الزيادة الملحوظة فى انتاج البيض.

- ادت معاملات الراحة الاجبارية المستخدمة الى ضمور واضح فى الاعضاء التناسلية للطيور الاناث منها والذكور، ففى الاناث اضمحلت المبايض واختفت الحويصلات المبيضية التى يزيد قطرها عن 5 مل وبالتالى انخفض وزن المبيض اما قناة البيض فقد حدث لها اختزال كبير فى الوزن والحجم والطول فى جميع اجزائها دون استثناء. وفى الذكور شوهدت نفس المظاهر تقريبا فى الخصيتين حيث انخفض وزنها وحجمها معنويا.

**التجربة الثانية :**

يمكن القول بصفة عامة بناء على نتائج هذه التجربة ان استخدام نظام التصويم المتبع فى هذه الطريقة كان اكثر فعالية كأداة لاحداث الراحة الاجبارية فى طيور السمان عن الطريقة المتبعة فى التجربة الاولى.

ويمكن القول بايجاز ان استجابة الطيور للطريقتين اتخذت نفس المسلك الا انها اختلفت فى مدى شدة التأثيرات المختلفة فكانت فى حالة نظام التصويم اسرع حدوثا واشد فعالية، علاوة على ذلك نجد ان الطيور فى حالة اتباع نظام التصويم بدأت الدورة الانتاجية الثانية مبكرة بحوالى ثلاثة اسابيع عن الطريقة الاولى وكانت اكثر مثابرة على الانتاج خلال هذه الدورة، لذلك فعلى ضوء نتائج تجارب الدراسة الحالية يمكن ان نوصى باستخدام نظام التصويم كأداة فعالة لاحداث الراحة الاجبارية فى طيور السمان لادخاله فى دوره انتاجية ثانية.