Impacts of Ambient Heat Stress on Growing Rabbit Performance and Carcass Traits

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Abstract
This study was conducted to investigate the effect of ambient heat stress (30 ± 2°C) on three rabbit breeds of both sexes. Rabbit of four weeks age of both sexes were enrolled in 3*2 factorial experiment. The animals were grouped into three groups 49 New Zealand white (NZW), 34 Californian (CAL) and 46 Rex (RX). Each group were sub-grouped into two sex sub-groups. The fortnightly growth performance (live body weight (BW), body weight gain (WG), and average daily gain (ADG)) were estimated. Moreover, by the age of 10th week, body length (BL); thoracic circumference (TC); abdominal circumference (AC); thigh circumference (THC); ear length (EL) and ear width (EW) and some carcass traits (skin weight, liver, heart with lung and trachea, kidneys, peri-scapular and peri-renal fat, hot carcass weight (HCW) and dressing-out percentage (DO%)) were recorded. The results of this study revealed that, the live body weight (BW) and average daily gain (ADG) of NZW (1130±18.1 g and 26.91±0.43 g/d, respectively) and RX (1120±16.4 g and 26.67±0.39 g/d, respectively) were significantly higher (P<0.01) than that of CAL (997±21.2 g and 23.75±0.50 g/d, respectively). The RX rabbits were significantly higher (P<0.01) for abdominal circumference (AC) and ear width (EW) compared with NZW and CAL. Significantly improved (P<0.01) dressing-out % (DO%) was recorded for CAL (60.03±0.37%) if they compared with NZW (58.46±0.33%) and RX (58.43±0.35%). In conclusion, breed variations had been evidenced for almost of growth, body measurements, and some of carcass traits, as NZW and RX showed better weight gain and average daily gain compared with CAL. However, CAL and NZW rabbits have lower body weight at slaughter than RX; they have the highest DO%.

Keywords: Rabbit, New Zealand White, Californian, body measurements, carcass

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INTRODUCTION
Rabbits production is one of the fast growing enterprises, this is mainly due to rabbits characteristics such as; fast reproduction, rapid growth rate, early maturity, efficient feed utilization and high quality nutritious meat [1–3] with low cholesterol level [4].Therefore, rabbits meat have high demand among different types of meat. The rapid expansion of such enterprises is facing with many challenges. Heat stress considered as most important hazard facing rabbits investment expansion in hot climatic zones. Heat stress defined as the stress created inside the animal body as physiological response for suffering from high ambient atmospheric temperature [5].

Rabbit can regulate their body temperature (homoeothermic animal) via physical, morphological, biochemical, and behavioural mechanisms to maintain their body temperature constant [6].

The ideal temperature for rabbits is ranging from 18 to 21°C [6, 7]. Therefore, summer heat stress resulted in poor growth performance and reproduction [8]. In concurrent work, we investigate the effect of long term heat stress upon both sexes of three rabbit breeds (New Zealand White (NZW) California (CAL) and Rex (RX)) to detect the ideal breed could be used under our Egyptian condition with minimal performance problems.
MATERIALS AND METHODS
The study was conducted at the Department of Animal Wealth Development, Faculty of Veterinary Medicine, Zagazig University, Egypt within the period from April to August 2014. A total of 129 newly weaned rabbits over the course of four weeks from three different commercial breeds (49 NZW, 34 CAL and 46 RX) of either sex. Young rabbit kits were arranged into three breeds*2 sexes factorial experiment. The animals were kept under ideal management system according to rabbit keeping standards. The temperature degree in the experiment was kept between 30 ± 2°C. Rabbits in each group were individually housed in universal galvanized wire cages and feed and water were offered ad libitum. Rabbits were fed a commercial pelleted mixture containing 17.5% crude protein, 14–16% crude fibre, 2% fat and 2300–2500 kcal/kg ME. The growth performance of growing rabbits was recorded fortnightly as, live body weight (BW), body weight gain (WG), and average daily gain (ADG). Just before the end of the experiment, rabbit body measurements were detected according to the procedures of Ref [9]. Body length (BL); thoracic circumference (TC); abdominal circumference (AC); thigh circumference (THC); ear length (EL) and ear width (EW) according to the following:

- **BL** = distance from the point of the shoulder to the pin bone
- **TC** = thoracic circumference behind the shoulder blades
- **AC** = abdominal circumference at the level of the 7th lumbar vertebra
- **THC** = the circumference of the thigh muscles
- **EL** = ear length from the bottom to the top of the ear
- **EW** = the distance across the middle of the ear

By the end of the experiment 10 males and 10 females rabbits were selected from each group weighted, humanely slaughtered and dressed according to WRSA recommendations [10]. The slaughtered rabbits were dressed and eviscerated just after complete bleeding. Weight of the skin including fore and hind paws, liver, heart with lung and trachea, kidneys, peri-scapular and peri-renal fat were recorded. The weight of the carcass including the head was detected and recorded as hot carcass weight (HCW). Dressing-out percentage (DO%) was calculated as (hot carcass weight divided by live weight × 100).

Statistical Analysis
After complete data recording and collection, the data which expressed as percentages were subjected to arc-sin transformation to obtain normal distribution before analysed. Body weight at slaughter was considered as a covariant when carcass traits were calculated and tested. Statistical analysis for all measured parameters was performed using the general linear model (GLM) produced by the Statistical Analysis Systems Institute [11]. Duncan multiple range test was used for means comparison. The analysis was done according to following statistical model:

\[ Y_{ijk} = U + B_i + S_j + (BS)_{ij} + e_{ijk} \]

- **Y** = An observation of each trait
- **U** = The overall mean
- **B** = Effect of breed (NZW, CAL and RX)
- **S** = effect of sex (male and female)
- **(BS)** = effect due to interaction between breed and sex
- **e** = random deviation due to unexplained source

RESULTS
Growth Performance
Concerning to the influence of heat stress on the rabbit breeds growth performance with regards to sex, as the rabbit growth performance possessed significant difference among different rabbit breeds and sex. Table 1 showed that till 8th weeks of age the three breeds had somewhat similar body weights, but at 10th weeks, the RX rabbits were significantly heavier (1678.9±19.13 g) than NZW (1593.20±23.93 g) and CAL (1584.30±31.13 g) at (P< 0.01). This was approved by higher WG and ADG of RX rabbits (346.63±15.42 g and 24.75±1.10 g/d for WG and ADG, respectively) compared with NZW (303.88±15.83 g and 21.70±1.13 g/d) and CAL (249.85±15.89 g and 17.84±1.13 g/d) at 8–10 weeks interval of age. Regarding the whole fattening period (4–10 weeks of age), WG and ADG of NZW (346.63±15.42 g and 24.75±1.10 g/d for WG and ADG, respectively) compared with NZW (303.88±15.83 g and 21.70±1.13 g/d), and CAL (249.85±15.89 g and 17.84±1.13 g/d) at 8–10 weeks interval of age. The RX rabbits were significantly (1784±15.89 g and 17.84±1.13 g/d) at 8–10 weeks interval of age. The RX rabbits were significantly (P<0.01). Data concerning the effect of sex on growth performance traits were not significantly differed (P≥0.05) from male to female.
Table 1: Effects of Breed and Sex on Body Weight, Body Weight Gain and Average Daily Gain (means ± standard errors).

<table>
<thead>
<tr>
<th>Variable (cm)</th>
<th>NZW</th>
<th>CAL</th>
<th>RX</th>
<th>Male</th>
<th>Female</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (g)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th week</td>
<td>462±17.20</td>
<td>586±18.50</td>
<td>558±15.30</td>
<td>512±14.30</td>
<td>548±16.10</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>6th week</td>
<td>909±29.00</td>
<td>1021±30.40</td>
<td>962±21.90</td>
<td>938±20.20</td>
<td>980±25.40</td>
<td>≤0.02</td>
</tr>
<tr>
<td>8th week</td>
<td>1289±24.30</td>
<td>1334±36.20</td>
<td>1332±24.70</td>
<td>1303±24.10</td>
<td>1331±20.10</td>
<td>0.46</td>
</tr>
<tr>
<td>10th week</td>
<td>1593±23.90</td>
<td>1584±31.10</td>
<td>1678±19.10</td>
<td>1597±19.30</td>
<td>1649±21.10</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Body weight gain (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4–6 weeks</td>
<td>447±17.90</td>
<td>435±20.00</td>
<td>404±11.40</td>
<td>425±11.30</td>
<td>432±16.00</td>
<td>0.12</td>
</tr>
<tr>
<td>6–8 weeks</td>
<td>379±20.60</td>
<td>312±18.60</td>
<td>369±17.90</td>
<td>356±14.30</td>
<td>350±18.30</td>
<td>≤0.04</td>
</tr>
<tr>
<td>8–10 weeks</td>
<td>303±15.80</td>
<td>249±15.80</td>
<td>346±15.40</td>
<td>293±11.90</td>
<td>318±15.50</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>4–10 weeks</td>
<td>1130±18.10</td>
<td>997±21.20</td>
<td>1120±16.40</td>
<td>1084±15.00</td>
<td>1100±18.25</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Average daily gain (g/d)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4–6 weeks</td>
<td>31.93±1.28</td>
<td>31.07±1.42</td>
<td>28.85±0.81</td>
<td>30.39±0.81</td>
<td>30.85±1.14</td>
<td>0.12</td>
</tr>
<tr>
<td>6–8 weeks</td>
<td>27.09±1.47</td>
<td>22.35±1.33</td>
<td>26.41±1.28</td>
<td>26.10±1.02</td>
<td>25.03±1.30</td>
<td>≤0.04</td>
</tr>
<tr>
<td>8–10 weeks</td>
<td>21.70±1.13</td>
<td>17.84±1.13</td>
<td>24.75±1.10</td>
<td>20.93±0.85</td>
<td>22.74±1.11</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>4–10 weeks</td>
<td>26.91±0.43</td>
<td>23.75±0.50</td>
<td>26.67±0.39</td>
<td>25.81±0.35</td>
<td>26.21±0.43</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

NZW = New Zealand White; CAL = Californian; RX = Rex.
Means within the same row within each category (breed or sex) not sharing the same letter were significantly different at P<0.05.

Body Measurements
Differences in animal body measurements showed significant differences among different breeds. Table 2, as RX rabbits had significantly higher AC (27.65±0.36) and EW (6.15±0.04) values compared with NZW (25.14±0.46; 5.84±0.07, respectively) and CAL (26.32±0.32; 5.71±0.06, respectively) at P<0.01. Moreover, both NX and CAL rabbits showed higher significantly TC (24.35±0.29 and 23.65±0.33 cm, respectively) over the NZW ones (22.32±0.31) at P<0.01. However, BL, THC, and EL were not significantly differed among different rabbit breeds at P>0.05. Neither sex nor breed sex interaction was differed significantly with regard to heat stress effect among different rabbit breeds (P>0.05).

Table 2: Effects of Breed and Sex on Body Measurements at 8 Weeks of Age (means ± standard errors).

<table>
<thead>
<tr>
<th>Variable (cm)</th>
<th>NZW</th>
<th>CAL</th>
<th>RX</th>
<th>Male</th>
<th>Female</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>21.80±0.40</td>
<td>22.96±0.39</td>
<td>21.87±0.41</td>
<td>22.29±0.26</td>
<td>21.98±0.44</td>
<td>0.11</td>
</tr>
<tr>
<td>TC</td>
<td>22.32±0.31</td>
<td>23.65±0.33</td>
<td>24.35±0.29</td>
<td>23.75±0.27</td>
<td>23.07±0.27</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>AC</td>
<td>25.14±0.46</td>
<td>26.32±0.32</td>
<td>27.65±0.36</td>
<td>26.77±0.33</td>
<td>25.94±0.35</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>THC</td>
<td>14.18±0.31</td>
<td>14.68±0.28</td>
<td>14.95±0.25</td>
<td>14.85±0.22</td>
<td>14.29±0.25</td>
<td>0.20</td>
</tr>
<tr>
<td>EL</td>
<td>10.60±0.12</td>
<td>10.45±0.16</td>
<td>10.63±0.10</td>
<td>10.62±0.10</td>
<td>10.50±0.11</td>
<td>0.50</td>
</tr>
<tr>
<td>EW</td>
<td>5.84±0.07</td>
<td>5.71±0.06</td>
<td>6.15±0.06</td>
<td>5.94±0.05</td>
<td>5.90±0.06</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

NZW = New Zealand White; CAL = Californian; RX = Rex; BL = body length; TC = thoracic circumference; AC = abdominal circumference; THC = thigh circumference; EL = ear length; EW = ear width.
Means within the same row within each category (breed or sex) not sharing the same letter were significantly different at P<0.05.
Carcass Traits
Regarding to the carcass traits measures Tables 3, liver was an important edible part of the rabbit body affected significantly with rabbit breeds reared in heat stress condition. As, liver weight % was significantly higher in NZW (3.51±0.14) followed by RX (3.32±0.15) and CAL (2.90±0.16) at (P<0.05). While, DO% possessed significant improvement in CAL rabbits (60.03±0.37%) when compared with NZW (58.46±0.33%) and RX (58.43±0.35%) at (P<0.01). NZW rabbits showed significantly higher PSF % (0.28±0.01%) over RX (0.23±0.01%) and CAL (0.21±0.02%) at (P<0.05). Moreover, rabbit sex wasn’t affected significantly the rabbit production kept under heat stress with exception of skin production, as male rabbits produced more skin than female ones at (P<0.01).

Table 3: Effects of Breed and Sex on Carcass Traits at 10 Weeks of age (means ± standard errors).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Breed</th>
<th>Sex</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NZW</td>
<td>CAL</td>
<td>RX</td>
</tr>
<tr>
<td>BW (g)</td>
<td>1674±23.4</td>
<td>1681±22.6</td>
<td>1741±25.2</td>
</tr>
<tr>
<td>Skin%</td>
<td>16.75±0.28</td>
<td>16.97±0.31</td>
<td>16.47±0.30</td>
</tr>
<tr>
<td>Kidney%</td>
<td>0.69±0.02</td>
<td>0.71±0.03</td>
<td>0.77±0.02</td>
</tr>
<tr>
<td>H+L%</td>
<td>1.09±0.03</td>
<td>1.01±0.03</td>
<td>1.05±0.03</td>
</tr>
<tr>
<td>HCW (g)</td>
<td>978±13.0</td>
<td>1010±15.1</td>
<td>1017±15.8</td>
</tr>
<tr>
<td>Liver%</td>
<td>3.51±0.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.90±0.16&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.32±0.15&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>DO%</td>
<td>58.46±0.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>60.03±0.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>58.43±0.35&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>PSF %</td>
<td>0.28±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.21±0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.23±0.01&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>PRF%</td>
<td>1.18±0.04</td>
<td>1.10±0.04</td>
<td>1.18±0.04</td>
</tr>
</tbody>
</table>

NZW = New Zealand White; CAL = Californian; RX = Rex; BW = body weight at slaughter; H+L = heart and lung; HCW = hot carcass weight; DO = dressing-out; PSF = periscapular fat; PRF = perirenal fat.

DISCUSSION
Concerning to the body weight gain results, the body weight of CAL at the beginning of fattening period was higher than that of NZW, the later showed slightly higher final weight. These results were attributed to compensatory growth [12].

Either NZW or RX showed significantly higher daily and totally body weight gain compared with CAL during the whole fattening period. Supportive results were reported in previous work of References [13–15]. Also Maj et al. [16] reported the superiority of NZW over CAL for body weight at the age of 70 days to slaughter. Rashwan et al. [17] demonstrated significant variation among breeds for body weight at weaning (28 d) and at market (84 d) of age.

Rabbit sex showed no significant effect upon the growth traits, thus could be attributed to the slaughtering time of the rabbits was before onset of their sexual dimorphism [18].

The foregoing results were in agreement with those of References [19–21].

Generally, the body measurements results were agreed with those of References [22] and [23]. On the contrary, Isaac et al. [24] observed non-significant breed effect on the linear measurements at 8th week of age between NZW and CAL. The lake of rabbit sex effect upon the body measurements could be due to weak sexual steroid hormones before rabbits puberty age. These results were agreed with those of [20, 25–27].

Dressing out % (DO %) possessed significant differences among different Rabbit breeds reared under heat stress, as CAL increased the DO% than either NZW or RX. Significant effect of genotype on DO% was detected by some authors [28–30]. Contradicted results were obtained by [31–33]. Baiomy and Hassanien [34] found that dressing yield was higher in NZW than CAL, but not significant. Regarding to sex effect, collaborated results were reported in previous studies [32, 35, 36].
CONCLUSION
Rabbit breed variations influenced growth, body measurements, and some of carcass traits under heat stress conditions significantly. NZW and RX had better weight gain and average daily gain under heat stress compared with CAL. RX rabbits had higher body weight at slaughtering time than NZW and CAL however, the latter two breeds had higher dressing %.

Ethical Statement
All procedures concerning animals were conducted according to the Zagazig University Animal Ethics Committee guidelines.

ABBREVIATIONS
NZW = New Zealand White;
CAL = Californian;
RX= Rex;
BL = body length;
TC = thoracic circumference;
AC = abdominal circumference;
THC = thigh circumference;
EL = ear length;
EW = ear width;
BW = body weight at slaughter;
H+L = heart and lung;
HCW = hot carcass weight;
DO = dressing-out;
PSF = periscapular fat;
PRF = perirenal fat.

REFERENCES


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