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IMPACT OF WATER SALINITY ON RABBITS PERFORMANCE

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ABSTRACT

This review is focusing on the impact of water salinity on rabbit's physiological, reproductive and productive responses, since the rabbits did not take a great interest in this respect. It was found from the trials that, water salinity with less or equal 3000 ppm TDS may improve both does and their progeny through increasing mineral requirements, water and feed consumption, then daily weight gain and body weight, and doe's milk yield are increased with no negative impacts on blood hematology and biochemical parameters. Meanwhile, increasing salts level in drinking water (more than 3000 ppm TDS) caused negative effects such as decreasing feed intake then body weight decreased which caused a decline in carcass weight and its components. Also, litter size and litter weight decreased. In addition, blood metabolites and metabolic hormones including total protein, albumin, globulin, glucose, and thyroid hormones were reduced. Furthermore, both male and female fertility markedly deteriorated. In contrast, some minerals increased with increasing level of salinity such as potassium and phosphorus, body water retention, urea nitrogen and creatinine also increased due to kidney failure.

So, in case of increasing level of water salinity (more than 3000 TDS) simple treatments should be applied such as diluted the saline water with fresh water in order to alleviate and minimize the negative impacts of salinity on rabbit's productive and reproductive performance.

Key words: Salinity load, physiological traits, reproductive efficiency, productive performance, rabbit,.

INTRODUCTION

Rabbits could become important meat animals in many countries, particularly developing nations with high human population density and shortage of high quality grain and plant protein sources **(McNitt *et al*., 2013).**

Rabbits offer number of several advantages over the other livestock because of their several distinctive characteristics which present in; high potential for reproduction, rapid growth rate, short generation interval, limited vital space rearing, great ability of using forages and byproducts as diet and inexpensive tools equipment for raising **(Abdel Rahman *et al.*, 2005).** Rabbit production cloud be realized depending on several factors including research to bring actual productivity closer to potential limits and increase consumer acceptance of rabbit's meat, because there is a worldwide phenomenon that people who readily accepted chicken, cattle and other livestock meat, find the idea of eating rabbit meat is difficult to accept **(McNitt *et al*., 2013).** In spite of, healthiness rabbit meat which represent in; highly nutritional quality, tenderness, high amount of protein, juiciness and low amount of fat **(Das and Bujavbarue, 2005),** their consumption in Egypt is still low, because rabbit farming is still unstable due the problems facing their production. So, such industry required more efforts from scientific institutes to face these problems and help in developing it **(Mohammed *et al*., 2013 & Abdel-Rahman and Ashour, 2023)** in order to get their benefits in solving a part of meat shortage and overcoming the gap between demand and supply of animal protein specially after the appearance of Avian Influenza disease in many countries including Egypt **(Safaa *et. al*., 2008).**

In Egypt, about 88-90% of this population is in the hands of small-holders and 10-12% belonged to large commercial project sector .The most breeds that are reared in Egyptian rabbit farms are floundering, Belgian, French, Erks, Hi-plus, Native, New Zealand, Chinchilla, Gabali and Moshtohor. The system of housing of rabbits was battery and ground breeding systems.

In Egypt , with the current trend in using desert lands that present 96% of the total area, there is a serious problem facing animal's productivity presents in saline water is already exist as main source of water in these areas **(Abdel Rahman *et al.*, 2005).** Egypt is arid and semi arid country, its location is contributing about one million square kilometer in the north-east of Africa and Sinai Peninsula of south west of Asia **(El-Hendawy, 2004).** Egypt is one of the countries suffering from severe salinity; for example 33% of the cultivated land (presents 3% of total area in Egypt) is already salinized **(Ghassemi *et al.*, 1995).** The main reasons of salinity problem are; the annual rainfall (> 25 mm), hot climate during summer season (temperature ranged between 35-45°c); highly surface evaporation (1500-2400 mm/year); poor drainage system with 98% of the cultivated areas under low quality of irrigation (salinity up to 4.5 ds/m, (**El-Hendawy, 2004).**

Salinity is the amount of salts contained in water. It is general term used to describe the levels of different salts such as sodium, chloride, magnesium, bicarbonate, etc. It is also called the salts concentration and may be expressed in g/l of water or in mg/l (= part per million, ppm), and it is easily measured by electrical device. Also, considered an important factor determining suitability and utilization of drinking water (**Abdel Rahman *et al.*, 2005).** Meanwhile, sodic water is defined as presence of high level of sodium ions (such sodium chloride, NaCl) relative to other cations.

In case of consumption excessive salts in water a lot of serious problems will present, **Wilson (1966)** stated that high level of sodium depress appetite. Similarly, **Balnave and Gorman (1993)** cleared that the increased level of sodium chloride in drinking water leads to increase blood pressure. Also, decreases productive performance due to the change in osmotic regulation and its negative impact on optimal regulation of intracellular macromolecules.

Several studies have been conducted on goat, sheep, poultry and cattle to study the impact of water salinity on their physiological responses **(Schmidt-Nielson, 1976; Hussan, 1987; Balnave *et al.*, 1989 and Badawy, 1999).** Fewer literatures that concerning about the impact of salinity load on rabbit performance and are not much updated.

So, the objective of this review is focusing on the impact of water salinity on physiological, reproductive and productive responses of rabbits, with trying to find practical solutions that can be applied to solve salinity problem.

1. Water quality

Water is a critical nutrient for livestock, as with feed ingredients, livestock water should meet the nutritional need for the animals. An adequate and safe water supply is essential to the production of healthy livestock. Water that adversely affects the growth, reproduction or productivity of livestock cannot be considered suitable. When considering whether a water source is suitable, it is essential to test pH, salinity and chloride level.

The effect of salinity on animal health and productivity depends on; breed, age and consumed feed, water minerals content, ambient temperature and humidity. Classification of water salinity is presented in Table (1). Also, Table (2) presents the safe limits for several water minerals for livestock

2. . Salt tolerance of rabbits

Common salt contains both sodium and chloride, salt is unique in that animals have a much greater appetite for the sodium and chloride than for other minerals. Even though the body only contains about 0.2% sodium, it is essential

Tabel 1. Classification of saline waters

Water classification	Electrical conductivity dS/m	Salt concentration mg/l	Type of water
Non-saline	<0.7	<500	Drinking and irrigation water
Slightly saline	0.7 – 2	500-1500	Irrigation water
Moderately saline	2 – 10	1500-7000	Primary drainage water and groundwater
Highly saline	10-25	7000-15 000	Secondary drainage water and groundwater
Very highly saline	25 – 45	1 5 000-35 000	Very saline groundwater
Brine	>45	>45 000	Seawater

Table (2). Safe upper limits for several substances that may contained in water for livestock

Substance	**Safe upper limit of concentration (ppm)**
Aluminum (Al)	5
Arsenic (As)	0.2
Boron (B)	5
Cadmium (Cd)	0.05
Chromium (Cr)	1
Cobalt (Co)	1
Copper (Cu)	0.5
Fluoride (F)	2
Lead (Pb)	0.05
Mercury (Hg)	0.01
Nitrate+ Nitrite	100
Nitrite	10
Selenium	0.05-0.10
Zinc	24
TDS	10.000
Magnesium + sodium Sulfate	5
Alkalinity (carbonate + bicarbonate)	2

for life and is highly regulated. About half of the sodium in the body is in the soft tissues of the body; the other half in bones **(Grim, 1980).** Sodium makes up about 93% of the basic mineral elements in the blood serum and is the chief cation regulating blood pH. The ability of muscles to contract is dependent on proper sodium concentrations. Sodium plays major roles in nerve impulse transmission and the rhythmic maintenance of heart **action (Moses, 1980).** Efficient absorption of amino acids and monosaccharides from the small intestine requires adequate sodium. Animals can consume high salinity water for a few days without risk if given access to good quality water thereafter. If given a choice between highly saline and good quality water, animals will not drink the saline water. Water consumption will usually increase as salinity increases up to the point where they refuse to drink. Depressed water consumption will decrease feed intake and reduce performance. Abrupt changes from low salinity to high salinity water will have greater detrimental effects on animal performance than gradual changes. The amount of sodium and chloride tolerated in drinking water is largely determined by the total soluble salt content of the water. Consequently, the **NRC (1974)** guidelines for the use of saline waters by livestock and poultry are based on the total soluble salts (Table, 3).

In rabbits, **Marai *et al* (2010)** clarified the term of salinity as; NaCl tolerance is related to the ability of the organism to maintain the osmolarities, distribution and volumes of body fluids by means of homeostatic mechanisms.

Also, they stated that, consume rabbits to less than 3000 ppm as total soluble salts concentration in drinking water may enhance the productive and reproductive performance. This may occur as a result to the increase in feed consumption through improvement of the appetite by the accepted saline level. Similarly, the progeny traits may also be improved as a consequent to drinking their pregnant dams underground saline water or agriculture drainage water due to the consumed saline levels seemed to meet their dams' high requirements of minerals.

Contrarily, ingestion of 3000 ppm and more (high saline level) as total soluble salts concentration in drinking water caused the decrease in feed consumption. Thus, fewer substrates became available for enzymatic activities and hormone synthesis and heat production, which minimized productive and reproductive performances. Also, ingestion of saline drinking water leads to changes in the retention and excretions of minerals. The acute excess of Na Cl in saline water resulted in a gain in body water **(Marai *et al.*, 2008).** In other words, water retention is directly proportional to Na Cl concentration of drinking water as the body retains appropriate amounts of water when it is unable to excrete all the extra Na Cl **(Wilson, 1966 and Kamal *et al.*, 1984).**

Table (3). A guide to the use of saline waters for livestock and poultry (1974)

Total soluble salts contents in water, ppm	Comment
Less than 1000	These waters have a relatively low level of salinity and should present no serious burden to any class of livestock or poultry
1000-2999	These waters should be satisfactory for all classes of livestock and poultry. They may cause temporary and mild diarrhea in livestock not accustomed to them or watery droppings in poultry (especially at the higher levels) but should not affect their health or performance.
3000-4999	These waters should be satisfactory for livestock, although they might cause temporary diarrhea or be refused at first by animals not accustomed to them. They are poor waters for poultry, often causing watery feces and (and the higher levels of salinity) causing increased mortality and decreased growth, especially in turkeys.
5000-6999	These waters can be used with reasonable safety for dairy and beef cattle, sheep, swine, and horses. It may be well to avoid the use of these waters approaching the higher levels for pregnant or lactating animals. They are not acceptable waters for poultry, almost always causing some type of problem, especially near the upper limit, where reduced growth and production or increased mortality will probably occur.
7000-10000	These waters are unfit for poultry and probably for swine. Considerable risk may exist in using them for pregnant or lactating cows, horses, sheep, the young of these species, or f or any animals subjected to heavy heat stress or water loss. In general, their use should be avoided, although older ruminants, horses and even poultry and swine may subsist on them for long periods of time under conditions of low stress.
More than 10000	The risks with these highly saline waters are so great that they cannot be recommended for use under any conditions.

Consequently, total body water and water turnover rate (which are indicative of water consumption) increase with increasing consumption of saline water **(Ayyat *et al.*, 1991).**

Marai *et al.* (2005) estimated the tolerance values to drinking saline water as 88 and 80% for NZW and California rabbits breeds, respectively, under the sub-tropical environment of Egypt, as follows:

Tolerance to drinking saline water = 100% – The average relative deviations (%; regardless the minus or plus signals) in all the traits studied due to the effects of salinity levels. The relative deviation in each trait is estimated as: Average of all differences in all the trait values (regardless the minus or plus signals) due to the effects of drinking saline water, divided by the average value of the trait when drinking tap water (which is considered as the control) x 100.

The relative deviations estimated by **Marai *et al.* (2005)** were 12 and 20% due to the effects of drinking saline water in NZW and California, respectively.

3. Impact of salinity load on physiological performance of rabbits:

The study of some blood aspects, in particular, metabolites, minerals, hormonal profile is an indicator for animal growth and for the managerial approaches towards improvement growth performance **(Ashour, 2001).** Therefore, it's important to study the effect of salinity on some blood components **(El-Badry *et al*., 2015).** Also, Blood act as a pathological reflector of the status of the exposed animals to conditions. The examination of blood provides the opportunity to clinically investigate the presence of metabolites and other constituents in the body of animals and it plays a vital role in the physiological and nutritional status of an animal **(Etim *et al.*, 2014).**

a. Hematological profile

Hematology refers to the study of the numbers and morphology of the cellular elements of the blood – the red cells (erythrocytes), white cells (leucocytes), and the platelets (thrombocytes) and the use of these results in the diagnosis and monitoring of disease **(Merck, 2012).**

Concerning the effect of saline water on hematological parameters, **Mohamed (1997)** found that, when rabbits drank saline water (3069 and 4841 ppm TDS) RBCs decreased in comparison with the group of tap water. This could be related to that excessive water intake caused hemodilution which might be the reason in the reduction of RBCs count.

Contradictory, **Hassan (2003)** proffered diluted sea water (6400 ppm TDS) and recorded a significant elevation in RBCs count with age advancement. Also**, El-Sherif *et al*. (2002)** recorded an elevation (7.5×10^6) in red blood cells (RBC's) in NZW rabbits drank sea water (diluted with tap water 1:5) in compare to group drank tap water (5.9×10^6). This elevation is due to reduced capillary resistance and increased osmotic fragility of RBC's which might the main cause of the increased production level of them. Same results obtained in other studies, **El-Hassanien and El-Sherif (1996)** in growing lambs and El-Badry *et al.* (2015) in ducks.

For WBCs, saline water caused an elevation in WBCs as confirmed by **Mohamed (1997)** who introduced saline water contains 3069 and 4841 TDS to California and NZW.

Table 4. Normal hematological values in rabbits (RAR, 2009)

Parameter	Reference value
PCV%	30-50
Hb (g/dl)	10-15
MCV (fl)	78-95
MCH (g/dl)	27-37
WBC (×1000)	4.5-11
Differential of WBC %	
Lymphocytes	40-80
Monocytes	1-4
Eosinophils	0-4
Basophils	1-7

Also, **Hassan (2003)** used diluted sea water (containing 6400 ppm TDS) starting from 15 week of age till 23 week of age recorded that WBCs increased with age advancement, and this could be attributed to saline water stress for long period caused gastroenteritis which led to leukocytosis

On contrary, **Ibrahim (1995)** reported a reduction in WBCs in goats received saline water contains 9188 and 13760 TDS. They attributed this reduction to salts stress for long period that caused alteration in WBCs production from bone marrow. Additionally, NaCl from 0.5 to 1.5 % led to an elevation in ACTH serum (in rams) which might cause restriction of lymphocytes particularly the eosinophils.

For hemoglobin concentration (Hb), the studies were disagreed with each other, some of these studies recorded a gradual increase in Hb concentration in rabbits drank sea water with age advancement **(El-Sherif *et al.*, 2002).** Meanwhile, a decline in Hb concentration was recorded by **Badawy (1999)** in sheep, who stated that, in case of exposure to stress, Hb reduced whereas erythrocytes increased significantly and attributed to the higher release from bone marrow in order to compensate for the Hb reduction concentration. Same results reported by. On the other hand, **Abdel-Rahman *et al.* (2000)** found no significant differences in Hb concentration between rabbits drinking sea water and tap water.

Backed cell volume percentage (PCV %) was increased in different studies such as **El-Sherif *et al*. (2002)** they found that diluted sea water resulted in elevation of PCV% increased from 47% to 50.7% in rabbits, and they stated that increased level of TDS in sea water till 6417 ppm caused an increase in PCV%. Also **El-Badry *et al.* (2015**) stated that PCV% increased (29.79, 34.74 and 35.24 %, respectively) with the increasing level of salinity (355, 2500 and 4500 ppm, respectively) , in ducks. This elevation in PCV% could be resulted from increased total body water with increase water intake. Also, elevation of Na in plasma leads to increased osmotic pressure and enhances water absorption thus increases blood volume **(El-Badry *et al.*, 2015).**

b. Metabolic profile

Blood biochemical parameters are used to monitor of physical, alimentary and environmental health of the animal **(Ashour, 2001).**

Saline water affects the concentration of total proteins, many studies found that total protein decreased and this may relate to the fact that water is held to the body fluids to dilute out the retained salts, resulting in dilution of blood proteins and so, decreases their levels **(Suckow and Douglas, 1997, Tietz, 1982 & Ayyat *et al.*, 1991)**. Same results were found in albumin, globulin and glucose they decreased because of the decline in feed intake, digestibility, as mentioned previously. **Suckow and Douglas (1997)** stated that total protein, albumin and globulin decreased is due to drinking saline water decreases the synthesis of RNA which in turn depressed the incorporation of amino acids for protein synthesis.

Ahmed and Abdel-Rahman (2004) studied the effect of natural underground saline water on growing rabbits (Baladi, Bouscat and California) and found that an increased in total lipids and cholesterol in the groups drank saline water compared to tap water (Table, 4). These increases could be attributed to the negative effect of the used water salinity on the renal system and thyroid hormones with a defect in lipoprotein metabolism resulting in increasing the high-density lipoproteins in the blood, which are the cholesterol-rich lipoprotein fractions. The elevated levels of cholesterol and lipoproteins resulted in a significant elevation in the blood total **lipids (Ellefson and Garaway, 1982; Abdel-Samee and El-Masry, 1992 & Pond *et al.*, 1995).** Other studies **(Hemsley *et al.*, 1975 and Marai *et al.*, 2010)** recorded a decrease in total lipids and they attributed this decrease to the decline in feed intake, digestibility and utilization of different nutrients. In White Leghorn hens drank well water, **Hassan and Abd-El Galil (2013)** found a decrease in glucose by 4.6%, total protein by 16.9%, cholesterol by 11.7% and total lipids by 4.2% compared to the group drank tap water.

c. Kidney functions

Kidney essentially works by filtrating plasma (glomerular filtration) and by

Table 5. Values of cholesterol, total lipids and total protein in rabbits drinking natural saline and fresh water according to Ahmed and Abdel-Rahman (2004)

Item	Breed	Treatment	
		Fresh water	Natural saline well water
Total protein	Baladi	7.1	3.8
	Bouscat	6.8	2.9
	California	7.2	3.1
Total lipids	Baladi	226.8	288.3
	Bouscat	233.9	292.1
	California	228.3	296.4
Cholesterol	Baladi	46.3	81.3
	Bouscat	51.2	92.5
	California	48.1	87.2

reabsorbing constituents of the tubule fluid from and by secreting constituents of plasma into various tubule segments. Also, kidney has an important transport work through; avoiding losses of metabolically valuable filtrate constituents such as D-glucose, amino acids and a lesser extent small to medium proteins. In the same manner, kidney prevents losses of the buffer $HCO3^-$ and ensures effective excretion of nitrogen compounds and toxic metabolites **(Greger, 1996).**

Concerning the impact of drinking saline water on kidney functions, Marai *et al.* (2010) stated that urea-N and creatinine were increased in rabbits as a result of drinking water containing high levels of salts (more than 3000 ppm TDS). This may be due to the kidneys' failure to excrete the excess Na. Although drinking high levels of salinity in water induces kidneys to excrete excess Na, urea-N and creatinine from plasma. Also, same results were obtained by **Hassan and Abd-El Galil (2013)**, who found in hens drank well water that creatinine and uric acid increased by 20.8% and 23%, respectively compared to group of tap water. **Abdel-Rahman *et al.* (2000)** attributed the increase in creatinine after drinking salt water to insufficiency of renal glomerular filtration and impairment of kidney.

d. Liver functions

Liver Function Test (LFT) is one of the most commonly requested screening blood tests. Whether for the investigation of suspected liver disease, monitoring of disease activity, or simply as 'routine' blood analysis. At a basic level the evaluation of liver enzymes simply gives information about the hepatic disorder. **Marai *et al.* (2010)** illustrate that serum Alanine transaminase (ALT) and serum Aspartate transaminase (AST) activities increased significantly with the increase in levels of salinity in drinking water.

Abdella (2014) studied the effect of using magnetic water on production, reproduction and physiological performance in rabbits, and found that ALT and AST were increased in group consumed well water (63.6 and 32.1 U/L, respectively) compared to group of tap water (60.8 and 28.6 U/L, respectively). And stated that magnetic water has the ability to enhance blood picture and health in male and female rabbits.

e. Mineral profile

Saline water causes a significant increase ($P<0.01$) in plasma Na, Ca, K, P and Cl may be due to the increase in water intake containing high levels of NaCl which cause apparent increase in the blood electrolyte concentrations and consequently result in stressing kidney function to excrete the excess of salts through urine. With regard to blood mineral levels, **Abdel-Samee and El-Masry (1992) and Ahmed and Abdel-Rahman (2004)** in rabbits, found that drinking natural saline well water resulted in a significant increase in the blood sodium and calcium levels and a significant decrease in the blood potassium and phosphorus concentrations (Table, 6). This could be attributed to the contrary trend between blood sodium and potassium concentrations to protect the body against hyperkalemia and so protect the body against muscle irritability. So, increased level of sodium ions in natural saline well water resulted in elevation rate of its reabsorption, thus cause a decline in reabsorption of potassium **(Crane, 1965; Grodsky, 1979; Tietz, 1982; Gary and Narang, 1985 & Abdel-Samee & El-Masry, 1992).** At the same time, increased calcium level in natural saline well water caused increased rate of its reabsorption and so, its blood level with decreased phosphorus level due to their reciprocal reverse relationship as the increased blood calcium level resulted in increased parathyroid hormone secretion which inhibits the renal tubules reabsorption of phosphorus **(Tyler, 1979).**

I. Hormonal profile

Various hormones controlling animal growth through its direct and indirect effects and influencing metabolic activity **(Ashour, 2001).** Thyroid hormones (TH) stimulate the basic metabolic rate via the metabolism of carbohydrates, lipids, and proteins. The actions are mediated by increasing the activities of specific enzymes that contribute to oxygen consumption **(Eshratkhah *et al.*, 2010).**

The concentrations of TH are affected by many factors including season, nutrition, age, gender, climate, breed, ovarian endocrine function, other physiological factors (i.e., pregnancy, lactation, and reproduction) and disease **(Huszenicza *et al.*, 2002).**

Table 6. Values of blood meniral in rabbits drinking natural saline and fresh water according to **Ahmed and Abdel-Rahman (2004)**

Item	Breed	Treatment	
		Fresh water	Natural saline well water
Sodium (mEq/L)	Baladi	138.3	181.2
	Bouscat	133.5	178.4
	California	141.1	188.1
Potassium (mEq/L)	Baladi	6.7	4.1
	Bouscat	7.1	3.9
	California	6.8	4.3
Calcium (mg/dl)	Baladi	11.2	13.9
	Bouscat	11.8	13.8
	California	11.6	14.1
Phosphorus (mg/dl)	Baladi	7.1	5.7
	Bouscat	6.8	5.4
	California	7.3	5.9
Magnesium (mg/dl)	Baladi	5.5	5.9
	Bouscat	5.1	5.7
	California	5.8	6.1

Also, thyroid hormones are affected by salinity, Ayyat *et al.* (1991) found in rabbits drinking saline water that T4 concentration decreased (33.3, 31.2, 24.3, 20.7 and 18.3 ng/ml, respectively) with the elevation level of salinity (control, 1500, 3000, 4500 and 6000 ppm TDS, respectively). Also, T3 show same trend of T4 which decreased gradually (decreased from 0.72 in control group and reached to 0.50 ng/ml in group drank saline water with 6000 TDS). Also, they cleared that level of water salinity caused increase in osmotic pressure in body fluids of rabbits; this may decrease thyroid hormones which in turn may decrease RNA in liver thus decrease incorporation of amino acids into protein. So, all these decreases lead to depression in final body weight, daily gain and total body solids

In the same manner, **Habeeb et al. (1997)** recorded a decline in T3 level (declined from 120 to 86 ng/dl) with increasing the level of water salinity (from 2000 to 5000 ppm).

On contrary, **Amer (1990)** found that a significant increase in T4 concentration in lactating goats received saline water containing NaCL (1.8%).

Concerning the effect of water salinity on testosterone level in rabbits buck, **Attia *et al*. (2015)** found that testosterone level decreased in bucks consumed well water (0.497 ng/ml) compared to tape water (0.561 ng/ml). Meanwhile, in the group consumed magnetized water testosterone level increased (0.609 ng/ml) thus, may have led to increase sexual desire as demonstrated by the decrease in reaction time and increase both fertility and semen quality **(Tomer *et al.,* 2005).** In addition, the mass motility and fertility were significantly correlated **(Attia and Kamel, 2012).**

Cortisol and corticosterone are the principle glucosides of the adrenal cortex. Cortisol predominates in rabbit, mouse and rat, **Ahmed and Abdel-Rahman (2004)** found that serum cortisol level of the experimented Baladi, Bouscat and California rabbits as a result of drinking fresh tap water and natural saline well water were 1.51, 1.62, 1.57 and 1.81, 1.88, 186, respectively. And they stated that cortisol level did not record a significant effect of drinking natural saline water on cortisol level in rabbits.

Also, large ruminants are intermediate case while cortisol is the major corticosteroid secreted by sheep **(Linder, 1959 and Paterson, 1964).** Studies on the circulating levels of adrenal corticosteroids showed a marked rise of these levels after exposure to any stressful conditions **(Elizabeth and Huda, 1985; Shutt *et al.,* 1988; Minton and Bleacha, 1990 and Parrott, 1996).**

4. Impact of salinity load on reproductive performance of rabbits

a. Bucks performance

Undoubtedly, male rabbits are the basis of reproductive success, but they have not received the attention they should have **(Alvarino, 2000).**

The farmer’s ability to breed his animals successfully has high dependence on the fertility status, which affected by environmental factors and caused a decrease in semen quality and fertility **(Attia *et al.,* 2013).** The relevance of sexual behavior in farm animals can be assessed using various parameters. The main parameters for measuring reproductive performance in male are; sperm motility, live/dead spermatozoa and proportion of morphologically deformed sperm **(Umesiobi *et al.,* 2000 and Ogbuewu *et al.,* 2007).** Also, **Alvarino (2000)** mentioned that semen quality in rabbits could be measured through pH which ranged between 6.8-8.4 (just after semen collection).

Many researchers studied the effect of drinking saline water on fertility and semen quality. In rabbits bucks, Attia *et al.* (2015) found that tap water significantly improved reaction time, fertility, sperm concentration, mass motility and total live sperm compared to group drank well water (Table, 7).

Table (7). Effect of water type on reaction time, fertility and semen quality in rabbit bucks

Water type	Semen quality traits											
	RT Sec.	Fertility %	EV ml	SC $\times10^6$/ml	MM %	AS %	DS %	LS %	NS %	TLS	TNS	TFSF
Tap	**21.2**	**88.8**	**0.67**	**528**	**68.5**	**13.4**	**9.91**	**90**	**86.5**	**324**	**311**	**214**
Well	**27.2**	**84.7**	**0.67**	**468**	**57.7**	**15.3**	**13.5**	**86.4**	**84.6**	**272**	**266**	**156**

Where: RT. Reaction time; EV. Ejaculate volume; SC. Sperm concentration; MM. Mass motility; AS. Abnormal sperm; AS. Dead sperm; LS. Live spermatozoa; NS. Normal sperm; TLS. Total live sperm; TNS. Total normal sperm; TFSF. Total functional sperm fraction.

Also, they found that other semen quality such as abnormal sperm, normal sperm, live/dead sperm were significantly increased in group drank tap water compared to group drank well water. They concluded that drinking well water resulted in a decrease in rabbits buck fertility and semen quality. This indicates the negative effect of poor water quality on animal performance and welfare **(Attia *et al.*, 2013).**

Also, **Hassan and Abd-El Galil (2013)** reported in white Loghorn cocks that saline water resulted in a significant decrease in ejaculate volume, sperm concentration, total sperm output, sperm motility, total motile sperm and semen quality. These negative effects could be explained due to severe degenerated of testes tissue and aggregation of RBCs in central vein in sinusoids. Also, **Ashour *et al. (*2013) and Zaghloul *et al*. (2011)** cleared that drinking saline water causes stress on pituitary gland leading to alteration in gonadotropins releasing which control androgenic testes secretion thus decreasing semen quality and production.

b.* *Does performance

The optimization of reproduction performance is one of the main facts that assure high productivity on rabbit's farm. This requires management practices take into account the physiology and behavior of the animal's science environment, managerial and sanity aspects interfere with fertility and can impair it **(Morsy *et al.*, 2012).**

Ahmed and Abdel-Rahman (2004) mentioned that neither of average conception rate, gestation length, litter size at birth, viability of young at birth nor bunny birth weight was significantly affected by saline water, either with Baladi, Bouscat and California rabbits.

Same results were found **by Abdella (2014)** they recorded that, rabbits does that drank well water were gave kits with lower litter size at birth, number born alive, litter weight and milk yield. Also, found that well water produced milk containing lower value of fat, lactose and energy in compare to group drinking tap or magnetized water. This could be attributed to the negative effect of drinking well water which results in poor productive performance and physiological response **(Shehata, 2005, Marai *et al.*, 2005 and Attia *et al.*, 2013).**

Meanwhile, the increase in milk yield in magnetizing water could be explained according to **MTC (2006)** who noted that magnetic field leads to decrease melatonin hormone in milk thus increases IGF-I leading to increase prolactin by the impact of the endorphin hormone that increases the stimulation thus milk production will be increased. Meanwhile, **Ayyat *et al.* (1991)** and **Abdel-Samee and El-Masry (1992)** stated that drinking saline water leads to increase dam's milk yield which reflected the positively and significantly of their bunny health, weight and gain.

5. Impact of salinity load on productive performance

a. Water and feed intakes

Water requirements of domestic rabbits are relatively high. Rabbits can lose nearly all the fat and more than half the protein from their bodies and still remain alive, but a loss of one tenth of the water of the body will result in death. Furthermore, rabbits can live for a relatively long time without solid food, but lack of water produces very quick harmful effects **(Sandford, 1996).**

Abdel-Samee and El-Masry (1992) and Ahmed and Abdel-Rahman (2004) found that drinking natural saline water (in Buscat and California rabbits) increased both intakes of water and green forages (Berssem). This could be attributed to the need of water used in the excretion of most anions and cations through increasing water output. So, animals need more water and consume large amounts of green forages with high level of water. But, feed intake decline gradually with increasing water salinity level more than 3000 ppm **(Gad, 1996 and Marai *et al.*, 2005),** because high level of salinity reduces digestibility, absorption and utilization of protein and different organic matter **(Ayyat *et al.*, 1991).**

The same results were obtained by **Ahmed *et al.* (1989); Pond *et al.* (1995); Guyton and Hall (1996); Suckow and Douglas (1997).**

Qar and Abdel-Monem (2014) studied the impact of sea water on water and feed intakes in rabbits and they found that with increasing level of sea water both water and feed intakes decreased (Table 8).

Table (8). Feed intake and water intake of growing NZW rabbits as affected by using natural sea water.

Item	Feed intake (g/day)	Water intake (ml/day)
Control (0 sea water)	79.1	151.7
Control + 5% sea water	71.8	118.1
Control + 10% sea water	68.7	103.6
Control + 15% sea water	60.7	99.0
Control + 20% sea water	52.9	82.1

Growth performance

Form previous studies in rabbits **(Abdel-Samee and El-Masry, 1992 & Ahmed and Abdel-Rahman, 2004),** body weight of kits that their dam drank saline water was increased till weaning age, this could be attributed to increased dam's milk yield. Also, drinking saline water during pregnancy helps dam to meet its minerals requirements.

Meanwhile, after weaning, growth rate or body weight of kits declined by 13% in winter and 20% in summer and this is due to the negative effect of salinity on feed intake. In the same manner, **Habeeb *et al.* (1997)** found that body weight decreased in NZW and California rabbits (5 weeks of age) drinking three levels of water salinity (3000, 4000 and 5000 pm) and the rate of final body weight and daily gain declined with the increased level of salinity.

a. Carcass characteristics

Generally, carcass weight is affected by drinking saline water as mentioned by **Ayyat *et al.* (1991)**, they observed that rabbits consumed saline water containing 300, 4500 and 6000 ppm TDS have a lighter carcass weight and this may due to the decrease in body solids content. Additionally, they found ta reduction in kidney fat, they attributed this decrease to deterioration in fat metabolism. Also, an elevation in alimentary tract weight was observed, and this may due to increase in water retention thus decreases feed passage in digestive tract. With other decreases in dressing percentages have been noticed, decreased from 60.6 to 58.3%. Same results obtained by **Marai *et al.* (2005),** they found that carcass weight dropped and 3% of carcass component weight (trunk, hind-limbs, liver and kidney) also decreased significantly with the elevation of salinity level in drinking water. This could be explained by the depression in pre-slaughter body weight and feed consumption as mentioned previously.

Table 9. Impact of drinking-water salinity on rabbit growth performance

Salts added to water (g/L)	**0**	**1.5**	**3.0**	**4.5**
Water content (ppm)				
Ca	11	99	187	275
Mg	11	21	31	41
K	8	143	278	413
Na	399	901	1403	1905
Cl	107	753	1399	2045
Bicarbonates	320	395	470	545
Total minerals	906	2409	3912	5415
Live weight gain (g/day)	29.7±1.4	28.9±0.9	24.3±1.0	22.6±1.1
Feed intake (g/day)	125	139	126	124

Source: **Ayyat et al. (1991)**

Qar and Abdel-Monem (2014), they studied the effect of drinking saline water on growth performance in rabbits and divided them in to; group 1 (control drinking well water); group 2 (drinking well water 95% + Sea water 5%); group 3 (drinking well water 90% + Sea water 10%); group 4 (drinking well water 85% + Sea water 15%) and group 5 (drinking well water 80% + Sea water 20%)and found that that, rabbits carcass weight, dressing % and prime cuts % were decreased significantly with the increased percentage of sea water in drinking water, when compared with the control group. This decrease could be attributed to the decline in final body weight which is resulted of decreased feed intake and nutrient digestibility as mentioned previously.

Conclusion and practical considerations

When rabbits consume saline water containing ≥3000 ppm of TDS (appetible and favorable saline level) results in elevation in productive performance of rabbit does because they can get their mineral requirements during pregnancy period. Also, feed consumption increased due to improvement of appetite, digestibility and utilization of nutrient thus improve body weight and daily weight gain for does and their kits till weaning (due to increased doe's milk yield). Meanwhile, increased saline level in drinking water (more than 3000 ppm) leads to negative impact on productive performance, feed consumption and reproductive performance through reducing semen quality and buck fertility.

Also, caused kidney failure resulting in elevation in creatinine and blood urea nitrogen.

Simple treatments can be applied to handle with highly water salinity; by diluted with fresh water. But, if fresh water is not available, saline water could be magnetized, which improved water quality thus reflects positive effects on rabbits' performance (body weight, blood picture, semen quality) and health, such treatment may be more efficient in desert areas with limited water supply and well water is the main source of drinking.

Conclusively, *in case of increasing level of water salinity (more than 3000 TDS) simple* treatments should be applied such as diluted the saline water with fresh water in order to alleviate and minimize the negative impacts of salinity on rabbit's productive and reproductive performance.

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تأثيــــر ملـــوحة الماء على أداء الأرانـــــب

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هذه المقالة العلمية تهدف الي التركيز على تأثير ملوحة المياه على الاستجابات الفسيولوجية والتناسلية والإنتاجية للأرانب، حيث لم يتم الاهتمام بالأرانب بهذا الأمر كثيرًا. وقد وجد من التجارب أن ملوحة المياه التي تقل عن أو تساوي ٣٠٠٠ جزء في المليون من المواد الصلبة الذائبة تؤدي الي تحسين أداء أمهات الأرانب وخلفاتها وذلك لأن هذا المستوي من الملوحة يعمل علي توفير احتياجات الأرانب من المعادن، ومن ثم زيادة الوزن اليومي ووزن الجسم، وزيادة إنتاج اللبن للأمهات دون حدوث أي آثار سلبية على قياسات الدم المحتفلة. بالإضافة الي ، تسبب ارتفاع مستوى الأملاح في مياه الشرب (أكثر من ٣٠٠٠ جزء في المليون من المواد الصلبة الذائبة) حدوث انخفاض في كمية المأكول ثم انخفاض وزن الجسم مما تسبب في انخفاض وزن الذبيحة ومكوناتها. كما يحدث انخفاض في حجم الخلفات ووزنها عند الميلاد. بالإضافة إلى ذلك، يحدث انخفاض في المواد التمثلية بالدم مثل، البروتين الكلي والألبومين والجلوبيولين والجلوكوز وهرمونات الغدة الدرقية. وعلاوة على ذلك، تدهورت خصوبة كل من الذكور والإناث بشكل ملحوظ. وعلى النقيض من ذلك، ارتفعت بعض المعادن مع زيادة مستوى الملوحة مثل البوتاسيوم والفوسفور، واحتباس الماء في الجسم، ونيتروجين اليوريا والكرياتينين أيضًا بسبب الفشل الكلوي.

التوصية: لذلك، في حالة زيادة مستوى ملوحة المياه (أكثر من ٣٠٠٠ TDS) يجب تطبيق معالجات بسيطة مثل تخفيف الماء المالح بالماء العذب من أجل تخفيف وتقليل الآثار السلبية للملوحة على الأداء الإنتاجي والتناسلي للأرانب.

الكلمات الدالة: الأرنب، حمل الملوحة، الصفات الفسيولوجية، الكفاءة التناسلية، الأداء الإنتاجي.