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CONVENTIONAL AND G-BANDING KARYOTYPE VARIATIONS OF THREE DUCK BREEDS OCCURRING IN EGYPT

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ABSTRACT

In the present work, the chromosome variation and comparative analysis of conventional and G-banding karyotypes between three duck breeds (Pekin, Soudani and Baladi) occurring in Egypt were carried out. Almost all examined cells of the three studied duck breeds showed 7 macro-chromosome pairs and Z, W and 64 microchromosomes (less than 1 micron in size and so called microchromosomes). Some of karyological parameters such as chromosome length, q and p arm lengths, arm ratio, Intra chromosomal asymmetry degree (AsD) and karyotypic asymmetry (AsK) were calculated. Results showed notable differences of the karyotype characteristics between the three studied duck breeds. Likewise, the studies macrochromosomes showed three different categories of karyotypic formulas were obtained (1m+7sm+1st for Baladi, 3m+6sm for Pekin and 9sm for Sudani) including sex chromosomes. Into AsD and AsK parameters also varied among the studied breeds. There was visible variation in the G- banding patterns and their constructed physical maps of the seven pairs of autosomes and sex chromosomes between the three studied duck breeds.

KEYWORDS: Karyotype, macrochromosomes, Duck breeds and G- Banding

1. INTRODUCTION

Duck is one of the most important domestic avian species in the world and considered for centuries an important part of animal production in Egypt. In 2016, the duck population (*Anas* spp.) throughout the world reached 1.24 billion and 1.1 billion (89 percent) were in Asia. Duck populations occurred in Egypt is about 15.650 million birds produce about 64478 tons of meat (FAO, 2019). Pekin duck breed is taxonomically belonging to species *platyrhynchos*, Genus: *Anas*, subtribe *Anatina*, tribe: *Anatini*, Family*: Anatidae*, suborder: *Ansera*, order: *Anseriformes*, class: *Aves*, while Sudani and Baladi duck breeds are belonging to species *moschata*, genus: *Cairina*, subtribe: *Cairinina*, tribe: *Anatini* (Livezey, 1997). Avian genome and karyotype are characterized by a small amount of genetic material and having the smallest genomes of all amniotes (Griffin *et al.*, 2007) The diploid chromosome number of duck species (*Anas platyrhynchos and Cairina moschata*) were relatively the same in two species (Ata *et al.*, 2017). And their hybrids suggested 34 to 62 chromosomes (Sokolowskaja, 1935). The reports of Yamashina (1941 and 1942) determined 80 in males and 79 in females and explained that the difference between the two sexes might be due to W chromosome loss. In fact, it has now been generally accepted that the diploid chromosome numbers in birds range from 40 to 126, and the mode of the chromosome number in birds is $2n=80$ (Seo *et al.*, 2016). Karyotype consists of ten large and medium-sized macrochromosome pairs (including ZW) and 60 indistinguishable microchromosomes. Karyological observations on *Anas platyrhynchos* and *Cairina moschata* showed differences between them in chromosome No.1and Z chromosome. The short arm of chromosome one was longer in *Anas platyrhynchos* than that of *Cairina moschata*. Likewise, Z chromosome was subtelocentric in *Anas platyrhynchos*, while it was acrocentric in *Cairina moschata* (Islam *et al.*, 2013). The W chromosome was small sized subacrocrocentric in *Anas* breeds while it was acrocentric in *Cairina* breeds. On the other hand, significant differences were found in the relative lengths of chromosome nos (1, 2, 3, 6, 7 and 8) across the two studied duck species (*Anas platyrhynchos* and *Cairina moschata*) whereas; lengths of chromosome nos 4, 5, 9, Z and W) were relatively the same in the two species (Ata *et al.*, 2017).

Conventional banding techniques facilitate differentiation of bird chromosomes (Bitgood and Shoffner, 1990; Ata *et al.*, 2005). One of the most commonly applied chromosome banding techniques is the RBG banding method. Another standard chromosome banding method is the CBG banding method (Wójcik and Smalec, 2007a and 2008a; Shahin *et al.*, 2014 and Ata *et al.*, 2019). Many Cytogenetic studies were targeted to develop a standard chromosome banding patterns for ducks

and geese (Apitz *et al.*, 1995; Denjean *et al.*, 1997; Andraszek and Smalec, 2007; W´ojcik and Smalec, 2007a, b; W´ojcik and Smalec, 2008a, b; Shahin *et al.*, 2014 and W´ojcik and Smalec, 2017). The only band pattern standard was for *Gallus domesticus* which approved by the International System for Standardized Avian Karyotypes (Ladjali-Mohammedi *et al.*, 1999). G-band is a technique used in cytogenetics to produce a physical giemsa banding mapping of condensed chromosomes and identify the pair of each homologous chromosome by their characteristic band patterns. G bands are obtained as a result of initial trypsin digestion and then applying Giemsa dye – GTG pattern or Leishman dye – GTL pattern (Seabright, 1971 and 1973). As a result, cytogenetic analyses of bird chromosomes are conducted on the basis of partial ideograms predominantly including the first 8-9 pairs of the largest chromosomes (Schmid et al., 2000 and 2005).

Consequently, this work aimed at describing the karyotypes of three duck breeds (pekin, soudani and baladi) occurring in Egypt by means of conventional staining and G-banding technique.

2. MATERIALS AND METHODS

2.1. MATERIALS

The present work was carried out at the Department of Genetics, Faculty of Agriculture, Minia University on three different duck breeds (Pekin, Soudani and Baladi). The Ducks were obtained from El-Serw Waterfowls Research Station, Dimiata, Animal Product Research Institute, Agriculture Research Center, Ministry of Agricultural, Egypt. To describe the karyotype of the three duck breeds including conventional and G-banding patterns. Bone marrow cells were taken from 12 birds, 4 (one female and three males) from each breed.

2.2. CONVENTIONAL KARYOTYPE ANALYSIS

2.2.1. CHROMOSOMAL PREPARATIONS

The mitotic chromosome preparations were carried out according to the method of Yosida (1973), with the modifications of Ata *et al.* (2005). Birds were injected with 0.1 ml of 0.02% colchicine intraperitoneally, 45 min later, the femurs and tibias were rapidly removed and the bone marrow was immediately flushed out with 0.56% KCl in conical centrifuge tube. Cell suspension was incubated at 37 °C for 30 min, and centrifuged at 5000 rpm for 10 min. The supernatant was discarded and 5 ml of cooled fresh prepared fixative solution (3 Methanol: 1 Acetic Acid) was added without disturbing the pellet, and incubated for 30 min at room temperature. Re-suspended the pellet and centrifuged is immediately done after washing by fixative. The supernatants were replaced with fresh fixative solution and re-centrifuged for three times. The white colored cell suspension was kept in the fixative solution and stored at 4 ^{o}C. Small drops of cell suspension were put onto the dried slide surface using a Pasteur pipet and the cell spots were left to dry at room temperature. Air dried slides were stained with 4% Geimza dye solution for 5 min at room temperature, then washed with tape water

2.2.2. KARYOTYPE ANALYSIS

For conventional karyotype analysis, 30 good metaphase spreads from each bird (male and female) were scored and photographed using Olympus BX51 microscope with a C-4040 zoom digital camera. Eight pairs of macrochromosomes including sex chromosomes were counted and measured using Soft Imaging System (SIS) program (version 3.0) to estimate chromosome length; long (L) and short (S) arm lengths. The arm ratio (L / S) for each macrochromosome were calculated and nomenclature classification of centromere positions was done according to the method of (Levan *et al.*, (1964).

To evaluate the significance of variation in chromosome parameters between the studied duck breeds, analysis of variance (ANOVA) and LSD values were statistically estimated using MSTAT program (Gomes and Gomes, 1984).

Karyotype ideogram was designed using software so called Karyotype that made by Altınordu *et al*. (2016). The primary function of this software is to allow efficient measurements of chromosomes and micro-photographic for karyotyping analysis. Karyotype software also has the potentiality for analyzing karyotype asymmetry indices such as Index of karyotype asymmetry (AsK) and inter chromosomal asymmetry index (A), which can recognize chromosome homology that based on chromosome length and arm ratio automatically or manually. The Karyotype measured metrics include chromosome length (CL), arm ratio (AR), centromeric index (CI), relative length (RL) and karyotype formula where chromosomes were arranged according to their total length. Karyotype parameters in addition to karyotype asymmetry index (AsK) were estimated as prsented in Table (1).

Table 1. Karyological parameters used to explore the karyotype of the three duck breeds

Karyological parameters	Abbreviation	Formula
Short arm length	S	
Long arm length	L	
Chromosome length	CL	L + S
Arm ratio	AR	L / S
Index of karyotype asymmetry	AsK%	Length of long arms in chromosome set / Total chromosome length in set × 100
Intra chromosomal asymmetry degree	AsD	1 − Mean S / L when = ≤1:4

2.3. G-BANDING PATTERNS OF DUCK BREEDS

Giemsa banding method was applied to identify the pair of each homologous chromosome by their characteristic banding patterns. The method of Yosida and sagai (1972), with some modifications by Ata and Shahin (1999) and El-Ashmawy *et al*. (2000) was applied. Slides were incubated in 2X (sodium chloride and sodium citrate) for one hour at 60 C° and then washed by distilled water. the slides were treated with 0.25% trypsin solution for 5-7 sec at 0 C°, incubated in 70% ethanol for 1 min and then washed with distilled water and stained in Giemsa stain solution (1:24 buffer, PH 7.0) for 3-4 min at room temperature. The slides were then washed in a distilled water and air-dried. About 25 metaphase spreads form both males and females at each duck breed were examined. G-banding ideograms were constructed using Adobe Photoshop 7.0 program.

3. RESULTS AND DISCUSSION

3.1. KARYOTYPE ANALYSIS

In order to characterize the karyotype variation among the studied duck breeds (Pekin, Soudani and Baladi), the largest eight chromosomes (including ZW) were identified as macrochromosomes. Table (2) showed the mean values of some karyological measurements such as lengths of long (L) and short (S) arms, arm ratio, and total chromosome length of these breeds. Several tables of ANOVA are not shown.

The remaining 32 pairs which appear as dots under light microscope were classified as micro-chromosomes at metaphase cells of the three studied breeds as shown in Fig. (1). In general, there were no significant differences in the total lengths (5.652, 6.454 and 6.744 µm) of the largest chromosome (pair no.1) between Balady, Pekin and Soudani duck breeds, respectively.

Table 2. Karyological parameters of macro-chromosomes (7 autosomes) and ZW sex chromosomes of the three duck breeds.

Breeds	Parameters	chromosomes								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**z**	**w**
Balady	**L**	3.878	3.098	2.388	1.990	1.680	1.406	1.268	1.702	0.898
	S	1.804	1.722	1.144	1.078	0.846	0.690	0.838	0.492	0.338
	CL	5.652	4.814	3.532	3.068	2.526	2.096	2.106	2.194	1.236
	AR	2.220	1.856	2.344	2.030	2.032	2.102	1.558	3.874	3.008
Pekin	**L**	4.202	3.052	2.516	1.988	1.516	1.280	1.132	1.738	0.918
	S	2.252	1.760	1.698	1.072	1.030	0.714	0.656	0.954	0.506
	CL	6.454	4.812	4.214	2.920	2.546	2.030	1.788	2.692	1.424
	AR	2.164	1.800	1.556	2.136	1.494	1.704	1.760	1.886	2.166
Soudani	**L**	4.762	3.550	2.934	2.248	1.754	1.448	1.146	1.922	0.916
	S	1.982	1.820	1.410	1.116	0.894	0.850	0.668	0.640	0.394
	CL	6.744	5.370	4.356	3.364	2.648	2.190	1.814	2.562	1.290
	AR	2.460	2.190	2.368	2.152	2.122	2.296	1.984	3.604	2.422
LSD value at alpha = 0.050		**1.156**	**1.020**	**0.9932**	**0.7746**	**0.4368**	**0.4974**	**0.4638**	**1.040**	**0.6005**

L= Long arm S= Short arm CL = Total chromosome length (L+S) AR= Arm ratio (L/S)

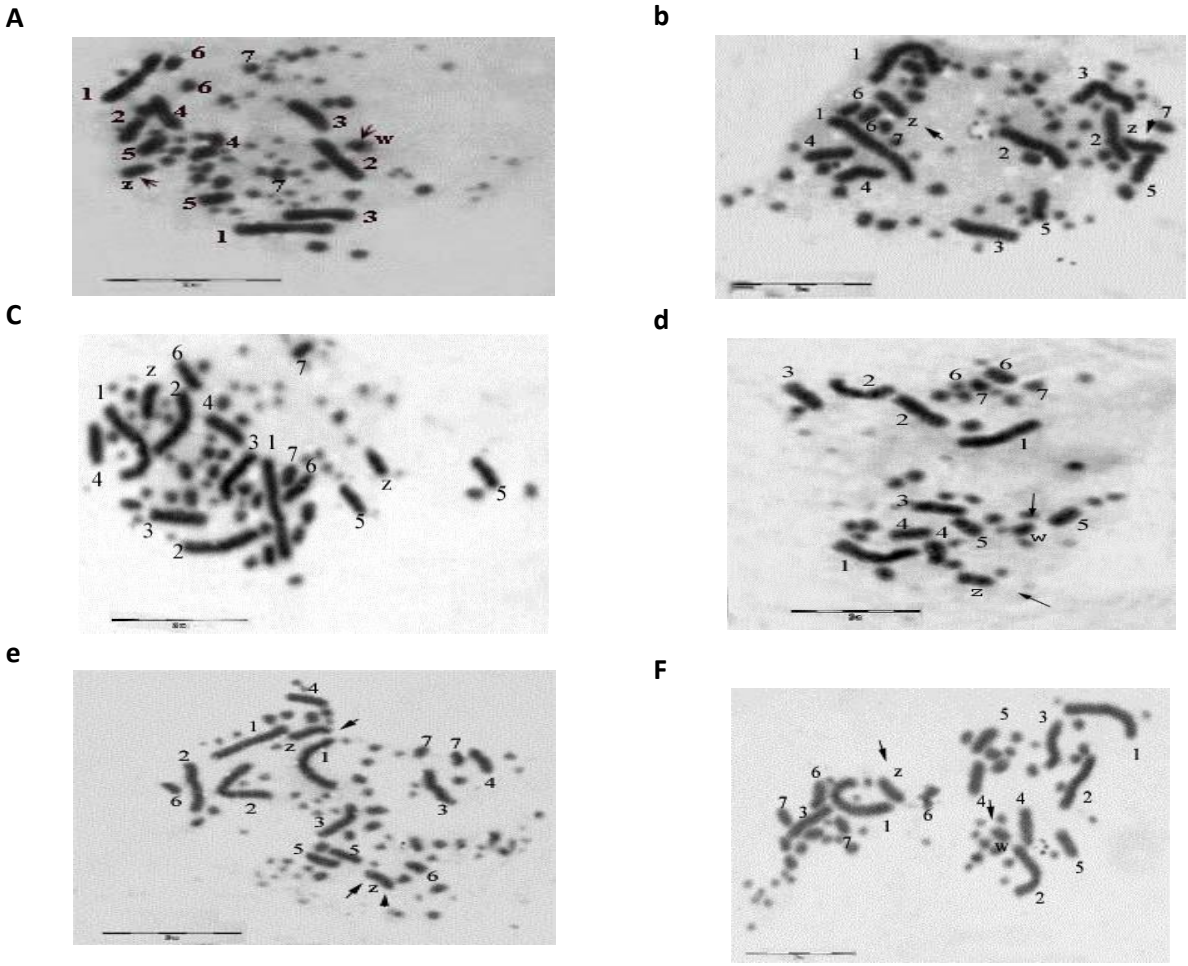

Fig 1. Metaphase spreads showing numbers of macro-chromosomes of both Males and Females of the three duck breeds: (a and b): male and female of Baladi duck breed, (c and d); male and female of pekin duck breed and (e and f): male and female of soudani duck breed. Arrows indicated to Z and W. Scale bare=20 µ

In the same manner, total lengths of pair nos. 2, 3, 4, 5, 6, 7, z and w were no significantly different between the studied duck breeds. In addition, the other karyotypic measurements such as lengths of the long and short arms and arm ratio of the analogous chromosomes in the studied three breeds showed no significant differences. However, data analysed by Karyotype software showed that the centromere positions of chromosome nos.3, 5, 6 were metacentrics in Pekin breed, while those of Baladi and Sudani were submetacentrics. Kayotype software analysis also showed that chromosome no.7 was metacentric and subtelocentric Z chromosome in Baladi, while those of Pekin and Sudani were submetacentrics (Fig. 2).

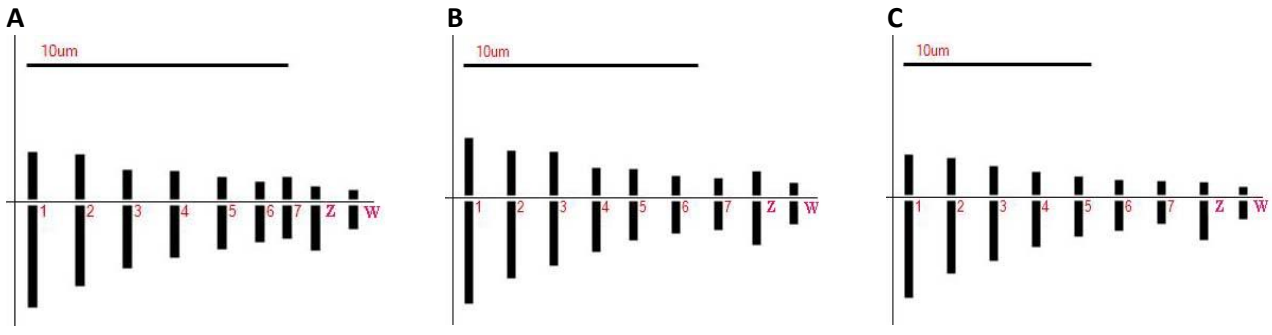

Fig 2. Karyograms showing the different categories of karyotypic formula in (A): in Baladi (1m+7sm+1st), (B): in Pekin (3m+6sm) and (C): in.Soudania (9sm), bar= 10 microns.

3.2. VARIATION OF KARYTYPIC FORMULA RESULTED AFTER DATA ANALYSIS WITH KARYOTYPE SOFT WARE

The karyotypic formula and asymmetry at metaphase cells of the three duck breeds were obtained after data analysis using software program (Karyotype) as shown Table (3) and Plate (1). Three different categories of karyotypic formula (1m+7sm+1st, 3m+6sm and 9sm) were observed in Baladi, Pekin and Soudani breeds, respectively. Values of karyotypic asymmetry (a ratio between the total lengths of long arms in haploid set and total lengths of all chromosomes of haploid number indicating dominancy of either meta-or sub-metacentric) ranged from 62.98% to 68.14% and were evidently different among the studied breeds (Table 3). Furthermore, data in Table (3) revealed that the intra chromosomal asymmetry degree (AsD) diverse among the three breeds (3C in Baladi; 1C in Pekin and 3C in Soudani).

Table 3. karyotype formula, karyotypic asymmetry (AsK) and karyotypic asymmetry (AsD) chromosomes of mean values three duck breeds (Baladi, Pekin and Soudani)

Parameters	Duck breeds		
	Baladi	**Pekin**	**Soudani**
*AsK	67.13%	62.98%	68.14%
**AsD	3C tend to submetacentrics	1C tend to subtelocentrics	3C tend to submetacentrics
Formula	2n=1x=1m+7sm+1st	2n=1x=3m+6sm	2n=1x=9sm

* AsK= Total length of L in a chromosome set / Total length of a chromosome set, ** AsD= asymmetry degree

To study the karyotypic variation among the three duck breeds (Baladi, Pekin and Soudani) means of the chromosome criteria (short arm, long arm, total length, arm ratio) of cells obtained from three different duck breeds were analyzed using the software Karyotype Altınordu *et al.*, (2016). Generally, almost all examined cells of the three studied breeds showed 7 macro-chromosome pairs and ZZ or ZW and about 66 dot or so called microchromosomes.

Duck species maintenance is currently a matter of serious concern due to the uncontrolled breeding, interbreeding, and hybridization of domesticated and natural populations of closely related species all over the world (Seo *et al.*, 2016). Differences in chromosome morphology including chromosome length (CL), arm ratio (AR), centromeric index (CI), relative length (RL) and karyotypic formulas between analogous chromosomes of the studied three duck breeds (Baladi, Pekin and Soudani) may due to occurring of structural aberrations such as centromeric reposition, translocations, inversions, deletions and/or duplications (Ata *et al.*, 2005; Islam *et al.*, 2014 and Shahin *et al.*, 2014). There are also huge differences between the karyotype reported herein and that early suggested by W´ojcik and Smalec (2007b) and (2008b), particularly in Z and W chromosomes (Ata *et al.*, 2017). Two possibilities for the process of chromosome rearrangements in the Z chromosomes were suggested, centromere moving that occurred in the ancestral acrocentric Z chromosome of *Galloanserae* or, a pericentric inversion that occurred in the ancestral acrocentric Z chromosome, followed by at least one large paracentric inversion (Ata *et al.*, 2007 and 2019). Systems include ZW (female heterogamety) in which the sex-specific element W is a more or less degraded version of the Z and is shorter because of deletion or longer because of insertion and amplification have also been suggested (Ezaz *et al.*, 2017 and Ata *et al.*, 2019). It is well known that using different software programs for analyzing chromosome data may result in misleading and making false differences between obtained karyograms (Altınordu *et al.*, 2016).

Indeed, the avian Z chromosome is highly conserved in size and morphology across all bird families, then comparative chromosome painting and sequence analysis showed high sequence homology across the most distantly related birds, and physical mapping revealed high levels of linkage homology (Nishida-Umehara *et al.*, 2007; Shetty *et al.*, 1999; Shibusawa *et al.*, 2004 and Zhou, 2004). There is no sex-specific SRY in birds and reptiles, but the DMRT1 gene, which is present on the Z but absent on W, is considered a good candidate sex determining gene (Marshall Graves and Shetty, 2001).

3.3. G-BANDING OF THREE DUCK BREEDS

Table (4) showed the mean numbers and types of G-banding after trypsin treatment of metaphase cells of three studied breeds (Baladi, Pekin and Sudani). Banding patterns either on p arm or on q of macro-chromosome pair no.1 in Sudani breed were clearly different from those found in Baladi and Pekin. Similarly, the other six large autosomes (somatic macro-chromosomes nos.2 to 7) showed variable banding numbers and patterns across the three studied duck breeds.

Table 4. mean number and patterns of G-bands on chromosome arms of Baladi, Pekin and Sudani duck breeds

chromosome Pair no.	Arm	breed	Numbers and types of G-bands			
			Faint and weak	Light and white	Dark and sharp	Total
1	P	Baladi	2	5	3	10
		Pekin	2	1	2	4
		Sudani	0	3	2	5
	Q	Baladi	2	7	5	14
		Pekin	2	7	5	14
		Sudani	1	5	4	10
2	P	Baladi	2	4	3	9
		Pekin	1	3	2	6
		Sudani	0	3	2	5
	Q	Baladi	1	4	4	9
		Pekin	1	4	2	7
		Sudani	1	2	1	4
3	P	Baladi	0	4	3	7
		Pekin	1	3	2	6
		Sudani	1	1	0	2
	Q	Baladi	1	3	2	6
		Pekin	1	5	3	9
		Sudani	0	2	1	3
4	P	Baladi	1	1	2	4
		Pekin	1	2	1	4
		Sudani	0	2	1	3
	Q	Baladi	1	3	2	6
		Pekin	1	5	4	10
		Sudani	1	2	1	4
5	P	Baladi	1	3	2	6
		Pekin	1	2	1	4
		Sudani	0	3	2	5
	Q	Baladi	2	4	3	9
		Pekin	1	1	0	2
		Sudani	0	3	2	5
6	P	Baladi	0	2	1	3
		Pekin	1	1	1	3
		Sudani	0	2	1	3
	Q	Baladi	1	3	1	4
		Pekin	1	2	1	4
		Sudani	0	3	2	5
7	P	Baladi	1	1	0	2
		Pekin	0	2	1	3
		Sudani	0	2	1	3
	Q	Baladi	0	2	1	3
		Pekin	0	2	1	3
		Sudani	1	2	1	4
Z	P	Baladi	0	2	1	3
		Pekin	0	2	1	3
		Sudani	0	2	1	3
	Q	Baladi	0	3	2	5
		Pekin	0	3	2	5
		Sudani	1	2	1	4
W	P	Baladi	1	1	0	2
		Pekin	0	3	2	5
		Sudani	1	2	1	4
	Q	Baladi	1	2	2	4
		Pekin	0	3	2	5
		Sudani	1	2	1	4

Fig. (3) also showed the microphotography of G-banded metaphase chromosome in both males and females of the three studied duck breeds. The faint, weak and dark G-bands were mapped on the karyogram of those breeds (Fig. 4). The constructed physical G-banding maps have confirmed the variation in numbers and localizations of G-bands among the studied duck breeds.

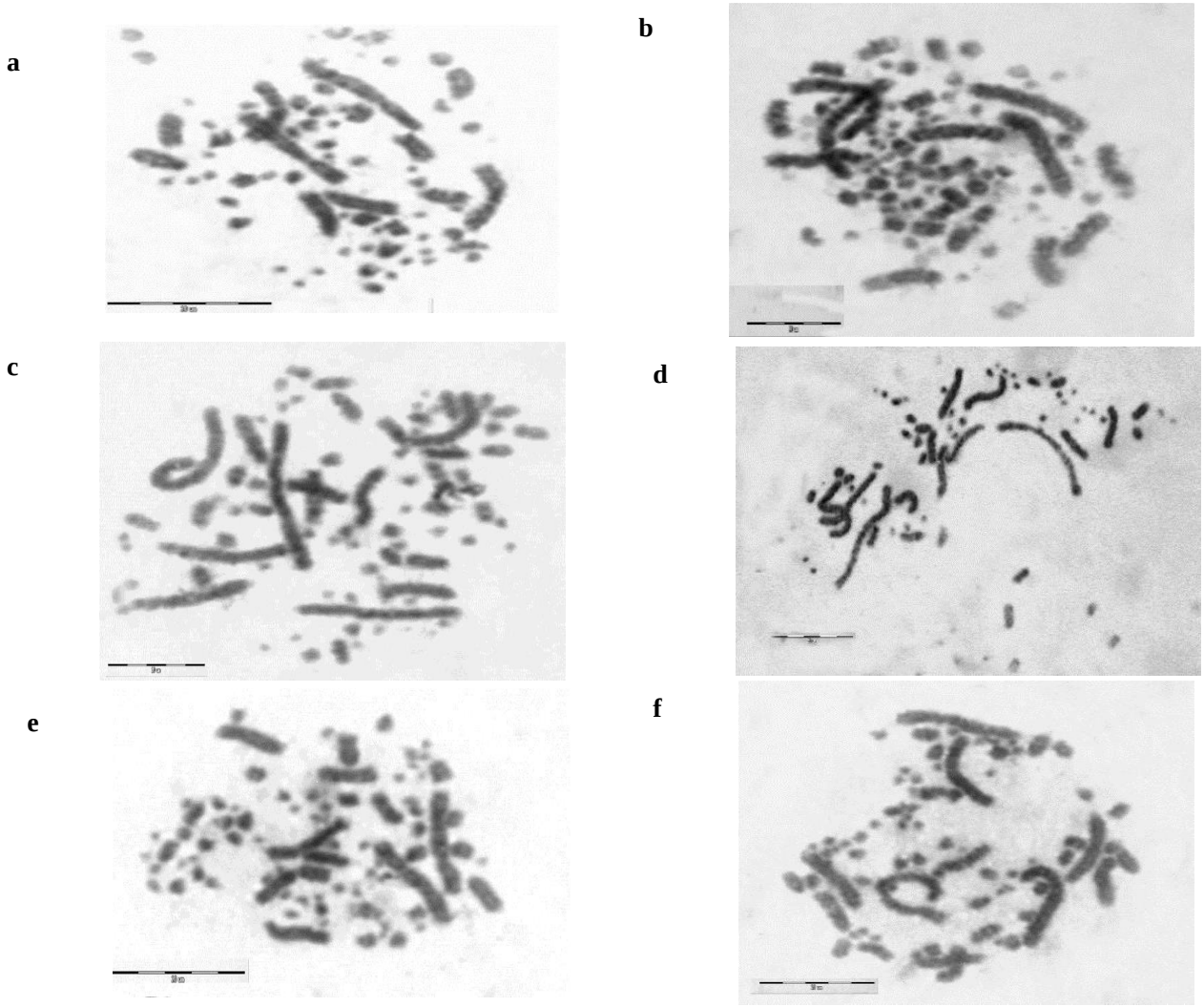

Fig 3. G-banding patterns of metaphase chromosomes in two cells of Baladi (a and b), Pekin (c and d) and Soudani (e and f) duck breeds. Scale bare=20µ

The differential banding technique applied to allow determination of G-banding pattern on the macro-chromosomes (including Z and W) of the three studied duck breeds (Baladi, Pekin and Sudani). Data reported herein disagree with those of Apitz *et al.* (1995), W´ojcik and Smalec, (2007b and 2017) and Ata *et al.* (2017 and 2019). Making G-banding karyotype in an individual or a species is fundamental for genome mapping attempt as both genetical and physical maps are made with respect to the chromosome position (Masabanda *et al.*, 2004). It was recommended by Ladjali-Mohammedi *et al.* (1999) and Schmid *et al.* (2000) to apply general guidelines developed for chicken to other avian species. Analysis of the duck karyotype was done in a limited number of researches works. Two of them presented G-banding pattern for 5 (Apitz *et al.*, 1995) and 12 chromosomes (Denjean *et al.*, 1997) of two duck species (*A. plathyrynchos* and *C. moschata*). Both teams described the Z and W hetero-chromosomes. There were some divergences in the banding pattern of duck chromosomes proposed (No. 3 and 2) that could be attributed to a different contraction during the cell cycle.

The differences of G-banding patterns between of duck species were remarkably found in the 2nd and Z chromosomes (Apitz *et al.*, 1995) or to the 3rd, 5th, 7th and Z chromosomes (Denjean *et al.*, 1997). The ideogram of eight G-banded macro-chromosomes and Z chromosome Denjean *et al.* (1997) cited in the First Report on Chicken Genes and Chromosomes (2000) differ from those presented in the original

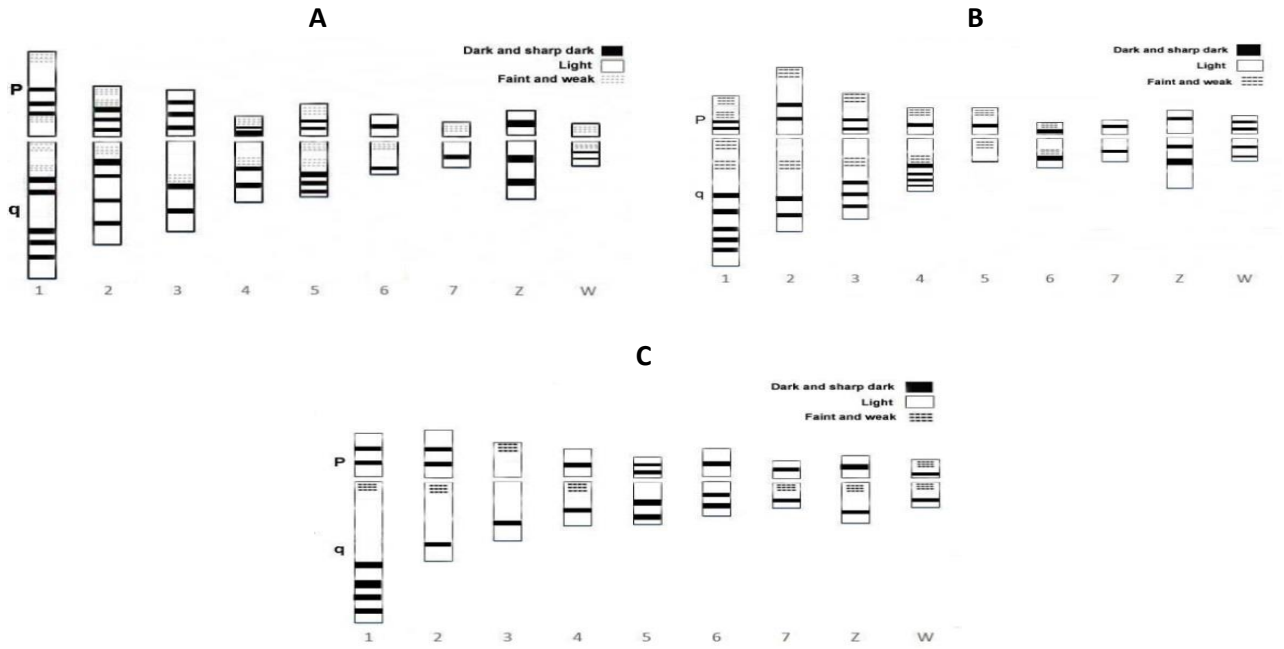

Fig 4. The physical G-banding maps of baladi (a), pekin (b) and soudani (c) duck breeds. Black indicates to the dark band, dots to the weak and faint and whit to the light bands

work in regard to the number of G positive bands (68 in the original paper vs 62 in the paper of Schmid *et al*. (2000). The karyotype comparison between duck species reflects differences of the 2nd, 3rd, 5th, 7th and Z chromosomes. Indeed, Apitz *et al*. (1995), Hailu *et al*. (1995) and Ducos *et al*. (1997) could determine differences in chromosome size between duck species. In conclusion, there is lack of comparable studies on R banding chromosomes in ducks.

4. CONCLUSION

This work aimed at describing the karyotypes of three duck breeds (pekin, soudani and baladi) occurring in Egypt by means of conventional staining and G-banding technique. Differences in chromosome morphology, G banding and karyotypic formulas between the studied three duck breeds were clearly observed. The application in the cytogenetic analysis of computer-generated chromosomal profiles that contain many bands makes it possible to determine a complete banded pattern even on short chromosomes individual of late metaphase. Duck breeds common in Egypt could be recognized from those present elsewhere, via the scattering and variability of banding patterns. Therefore, some molecular studies (under publication) will explain the genetic makeup of duck breeds occurring in Egypt.

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الملخص العربى

الإختلافات فى الطرز المجموعى الكروموسومى العادى والمجهز بالشرائط ج بين ثلاثة انواع من البط الموجود فى مصر

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فى هذه الدراسة تم توضيح التباين الكروموسومى وعمل تحليل مقارن للطرز المجموعى الكروموسومى العادى والأخر المعد بشرائط من الطراز ج بين ثلاثة أنواع من البط موجودة فى مصر هى االبلدى والبكينى والسودانى، ولقد اتضح أن معظم الخلايا االمفحوصة فى الأنواع الثلاثة للبط تحتوى على سبعة أزواج من الكروموسومات الكبيرة وزوج كروموسوم الجنس (Z and W) بالأضافة لـ٦٤ من الكروموسومات الصغيرة والتى تسمى كروموسومات النقطة لشدة صغرها (أقل من ١ ميكرون فى الحجم). ولقد تم أيضا أخذ بعض القياسات المميزة للطرز المجموعى الكروموسومى مثل أطوال الكروموسومات الكبيرة وكذلك أطوال الأذرع الكروموسومية وقياس التجانس وعدم التجانس فى هذه الطرز الكروموسومية من حيث مواقع السنترومیرات، ولقد أظهرت النتائج وجود إختلافات ملحوظة بين هذه الأنواع الثلاثة من حيث صفات وخصائص الطرز الكروموسومية لها، ولقد اتضح أن هناك ثلاثة أنماط من معادلة الطرز الكروموسومى لكل نوع معادله خاصة به، وكذلك أظهرت النتائج وجود إختلافات فى المقياس الخاص بالتجانس وعدم التجانس فى الطرز المجموعى الكروموسومى بين التلاثة أنواع من البط تحت الدراسة، وأظهرت النتائج أنه أيضا توجد اختلافات فى أشكال الشرائط من الطراز ج فى السبعة أزواج من الكروموسومات الكبيرة وكذلك زوج كروموسومات الجنس بين البط البلدى والبكينى والسودانى من حيث عدد الشرائط فى الكروموسومات وكذلك فى الخرائط الكروموسومية المجهزة من هذه الشرائط.