RESULTS

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Part I: Body weight, wing surface area parameters and relative organ weights in the three studied birds.

In table (1) body weight, wing surface area and relative weights of assorted organs (heart, pectoralis muscles, liver, spleen, gizzard, and kidney) related to body weight were depicted, it in the three birds species, pigeon *(Columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and the moorhen *(Gallinula chloropus)*.

(1)Total Body Weight, W (g):

Body weight of the pigeon was significantly higher at ($p<0.01$) than that of the moorhen. Also body weight of the moorhen was significantly higher ($p<0.01$)than that of the buzzard (Table 1& Fig 1).

(2)Wing Surface Area, S (cm^2):

Table (1) and figure (2) demonstrated that the wing surface area of the buzzard was significantly high as compared to that of the pigeon and moorhen ($p< 0.01$). The wing surface area of the pigeon was significantly high ($p<0.01$) when compared with that of the moorhen.

Table (1) : Body weight, wing area parameters and relative organ weights in the pigeon *(Columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and the moorhen *(Gallinula chloropus)*

Organ	Pigeon			Buzzard			Moorhen		
	M ± SD	Range		M ±SD	Range		M ±SD	Range	
W (g)	372.800 ±23.7000	350.000 - 400.000	$^{++}\alpha$	133.800 ± 13.2000	120.000 -160.000	$^{++}\beta$	221.600 ± 9.5000	200.000 - 250.000	^{++}c
S (cm^2)	177.500 ± 6.9000	176.300 - 186.700	$^{++}\alpha$	205.000 ± 10.5200	198.700 - 217.000	$^{++}\beta$	109.100 ± .3000	103.100 - 118.300	^{++}c
Wing loading index ($g^{2/3}/cm^2$)	0.036 ± 0.0031	0.011 - 0.051	$^{++}\alpha$	0.018 ± 0.0013	0.012 - 0.026	$^{++}\beta$	0.045 ± 0.0014	0.024 - 0.063	^{++}c
Lh/wh (%)	1.430 ± 0.2800	0.600 - 1.640	α	1.340 ± 0.0500	1.270 - 1.400	β	1.300 ± 0.3000	0.900 - 1.600	c
H/ w (%)	0.800 ± 0.1300	0.600 - 1.170	$^{+}\alpha$	0.920 ± 0.0300	0.810 - 0.960	$^{+}\beta$	0.900 ± 0.0080	0.300 - 1.000	c
Pj/w (%)	4.300 ± 0.7100	2.700 - 5.800	α	4.600 ± 0.7100	4.080 - 5.500	β	4.500 ± 0.9000	3.900 - 6.200	c
Pn/w (%)	0.650 ± 0.0450	0.053 - 0.750	$^{++}\alpha$	0.290 ± 0.1700	0.110 - 0.460	$^{++}\beta$	0.700 ± 0.1500	0.500 - 0.820	^{++}c
P/w (%)	0.080 ± 0.0200	0.010 - 0.100	$^{++}\alpha$	0.040 ± 0.0090	0.010 - 0.060	$^{++}\beta$	0.030 ± 0.0200	0.010 - 0.060	c
L/w (%)	3.260 ± 1.2400	1.400 - 4.500	$^{++}\alpha$	1.600 ± 0.2300	1.400 - 1.900	$^{++}\beta$	1.500 ± 0.3000	1.100 - 2.190	c
G/w (%)	2.850 ± 0.5000	1.400 - 3.400	$^{+}\alpha$	1.390 ± 0.1000	1.100 - 1.700	β	2.400 ± 0.4000	1.700 - 3.000	^{+}c
K/w (%)	0.280 ± 0.1500	0.180 - 0.390	α	0.260 ± 0.0500	0.180 - 0.360	β	0.240 ± 0.0600	0.180 - 300	c

M = Mean 7 measurements SD = standard deviation

α = Relation between pigeon and common buzzard

β = Relation between pigeon and moorhen

c =Relation between common buzzard and moorhen

\+ = Significant difference at $P < 0.05$ (for t test)

++ = Significant difference at $P < 0.01$ (for t test)

+++= Significant difference at $P < 0.001$ (for t test)

W: body weight, S: wing surface area, Pj: pectoralis major muscle, Pn: pectoralis minor muscle, H: heart, Lh: heart length, wh: heart width, P: spleen, L: liver, G: gizzard, K: kidney.

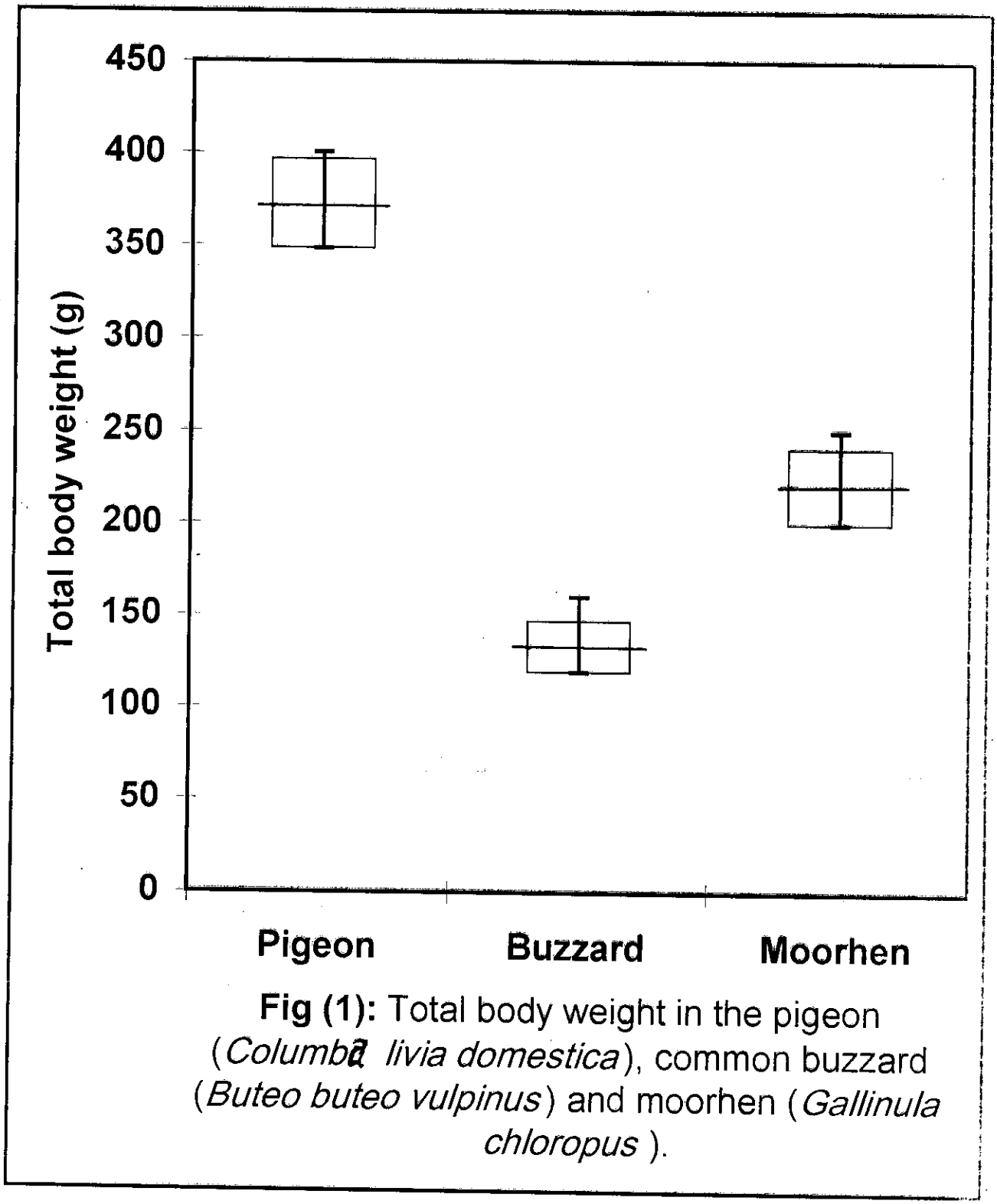


Fig (1): Total body weight in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

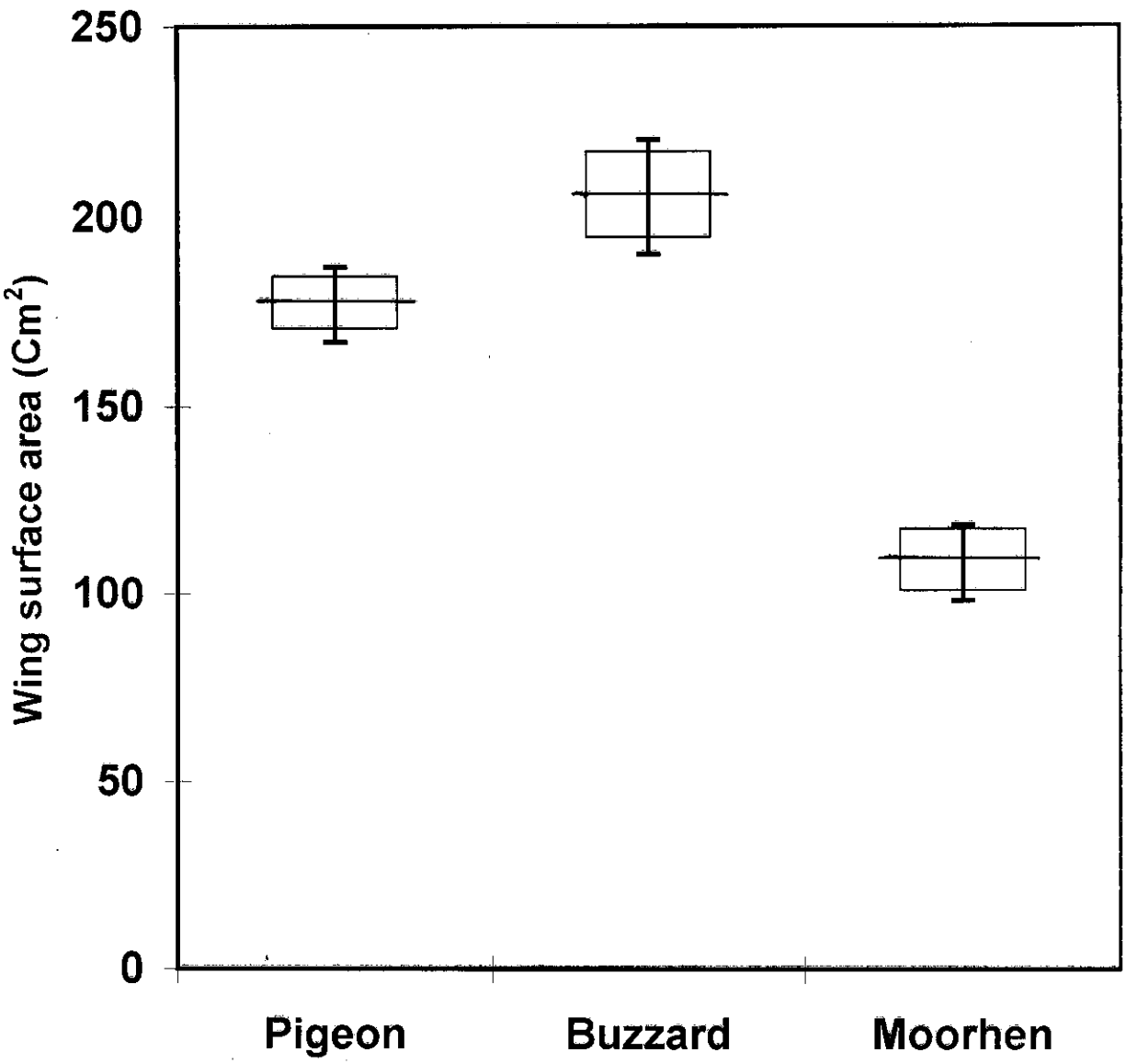


Fig (2): The wing surface area in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

(3) Wing Loading Index, ($g^{2/3}/cm^2$)

The wing loading index was significantly low ($P<0.01$) in the common buzzard as compared to that of pigeon and moorhen Moreover, the wing loading index of the moorhen showed a higher value than buzzard and pigeon (Table 1 and Fig. 3).

(4) The Heart Length To The Heart Width (Lh/Wh)

The relative heart length to the heart width of the pigeon showed nonsignificant difference with that of buzzard and moorhen. Also, the relative heart length to the heart width of the buzzard showed nonsignificant difference with that of the moorhen (Fig. 4and Table 1).

(5)The relative weight of the heart

The relative weight of the heart of pigeon showed a significant differences from those of the buzzard and moorhen ($p<0.05$).

The relative weight of the heart of the buzzard was significantly higher ($P<0.05$) than that of the pigeon, while, the relative weight of the heart of moorhen showed nonsignificant differences from those of pigeon and buzzard (Table 1 and Fig. 5).

(6) The relative weight of pectoralis major muscle:

The relative weight of the pectoralis major muscle to total body weight of the pigeon showed nonsignificant differences in relation to those of the buzzard and moorhen. Also, the relative

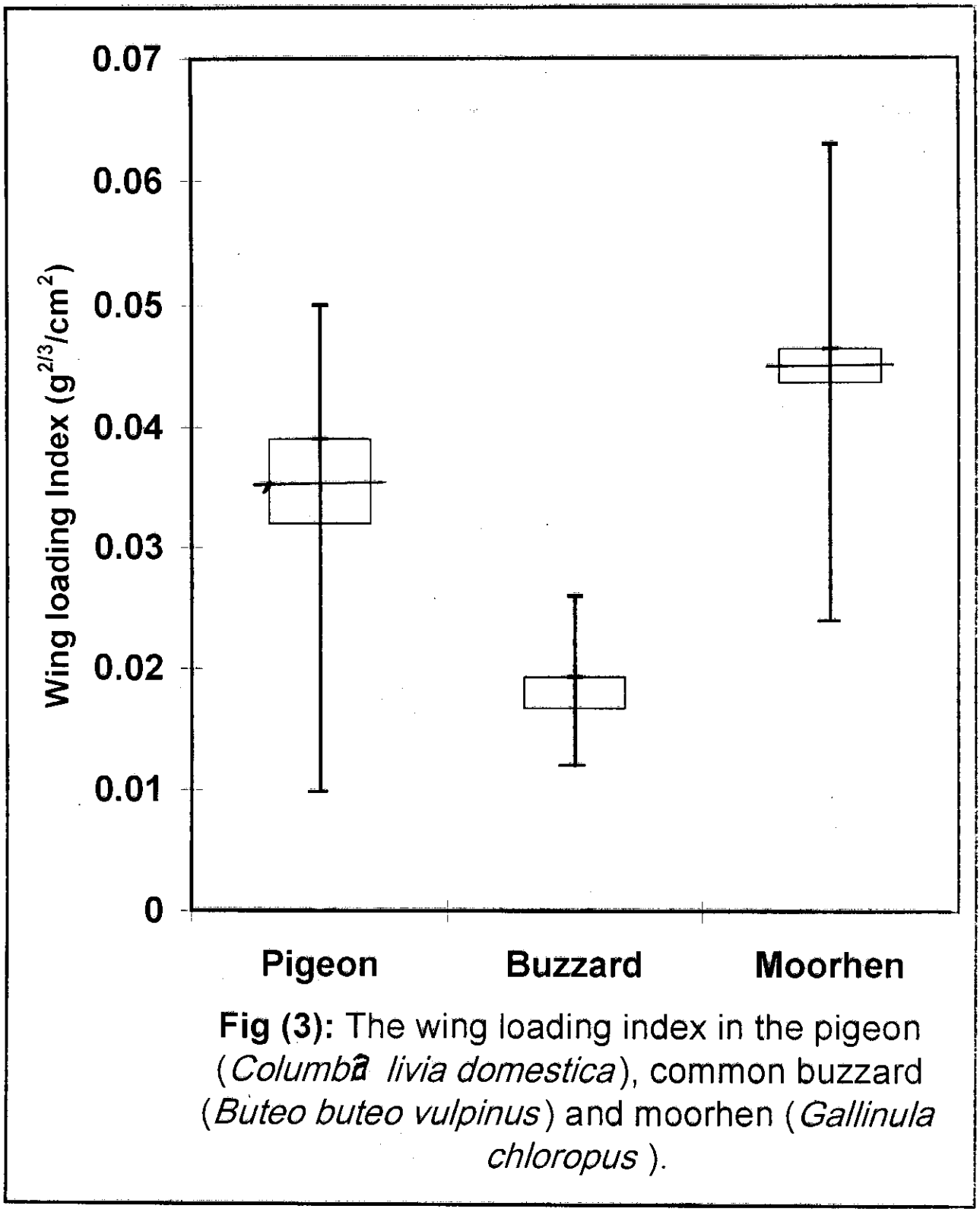


Fig (3): The wing loading index in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

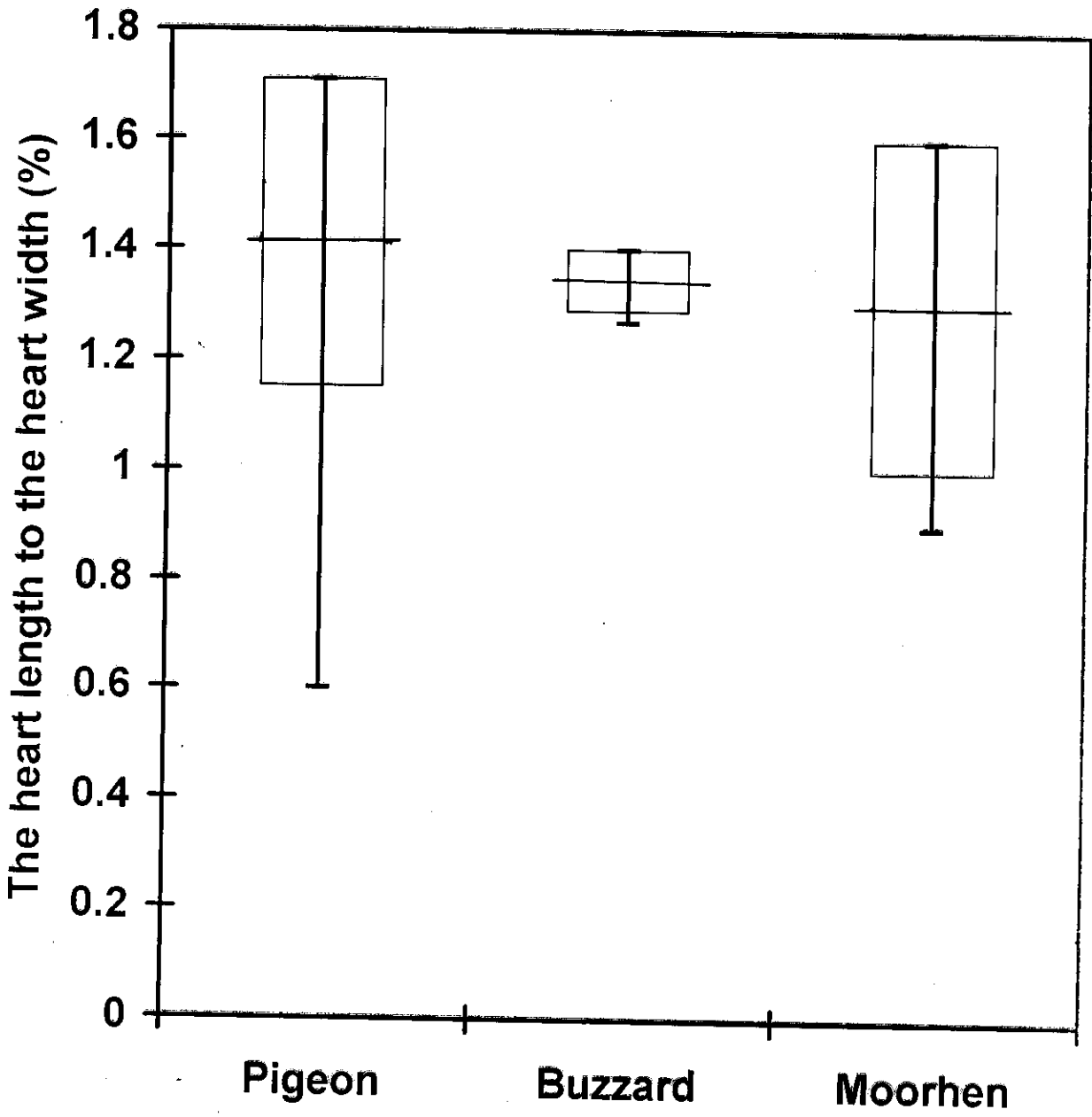


Fig (4): The heart length to the heart width in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

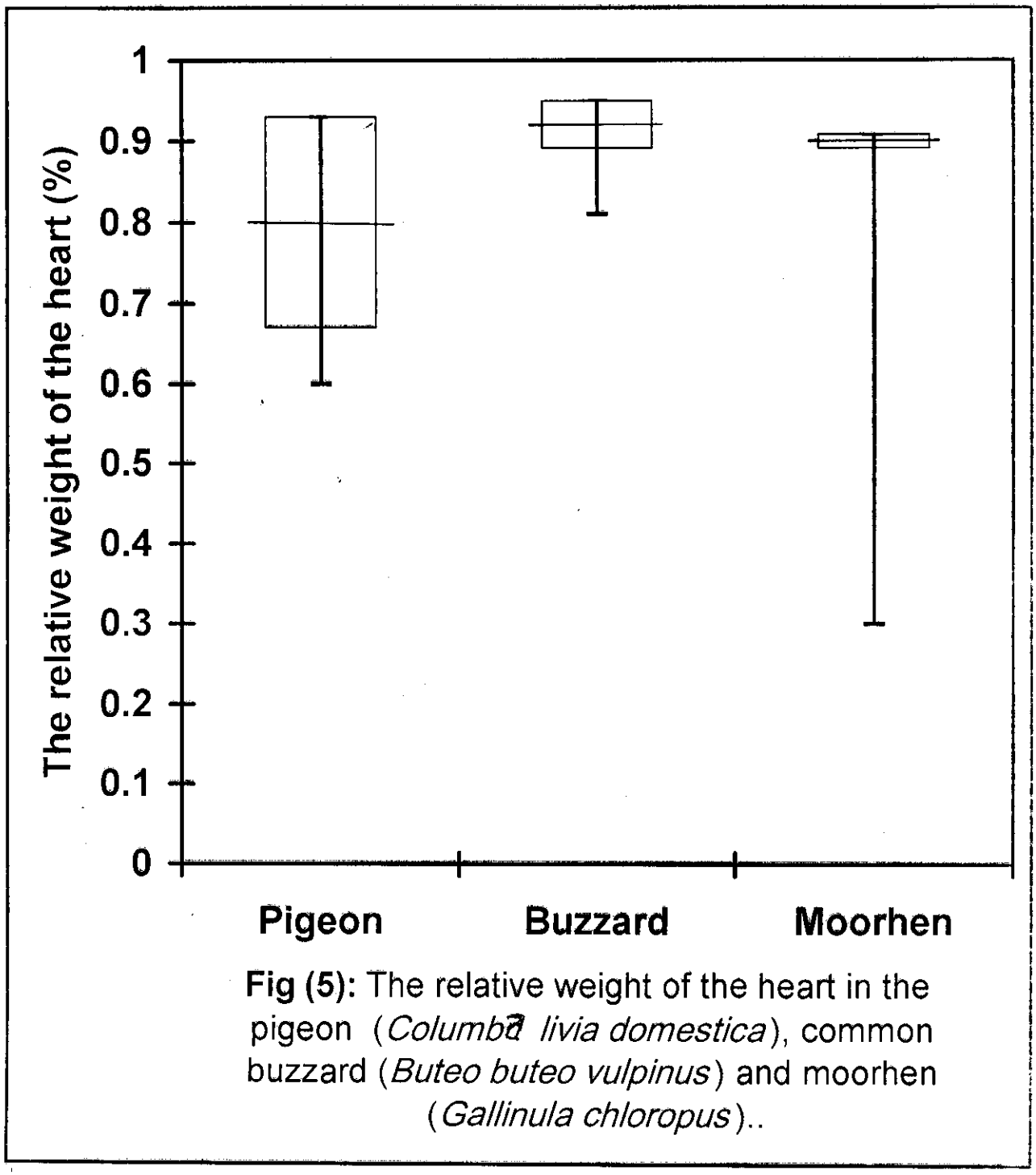


Fig (5): The relative weight of the heart in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*)..

weight of the pectoralis major muscle of the buzzard showed nononsignificant difference from that of the moorhen (Fig. 6 and Table 1).

(7) The relative weight of pectoralis minor muscle.

The relative weight of pectoralis minor muscle of the moorhen was higher than that of the pigeon and buzzard. The relative weight of pectoralis minor muscle of pigeon and moorhen were significantly higher than that of buzzard ($P<0.01$). (Table 1 and Fig. 7).

(8) The relative weight of spleen

The relative weight of spleen to the total body weight was significantly high ($P<0.01$) in the pigeon as compared to that of moorhen, while that of buzzard showed non significant difference from those pigeon and moorhen (Table 1 and Fig. 8).

(9)The relative weight of liver

The relative weight of liver to the total body weight of the pigeon was significantly higher ($P<0.01$) than that of the buzzard and moorhen. While the relative weight of buzzard liver showed nonsignificant difference from that of the moorhen. (Table 1 and Fig. 9).

(10) The relative weight of gizzard

The relative weight of gizzard of the buzzard was significantly low ($P<0.05$) as compared to that of the pigeon and moorhen, while

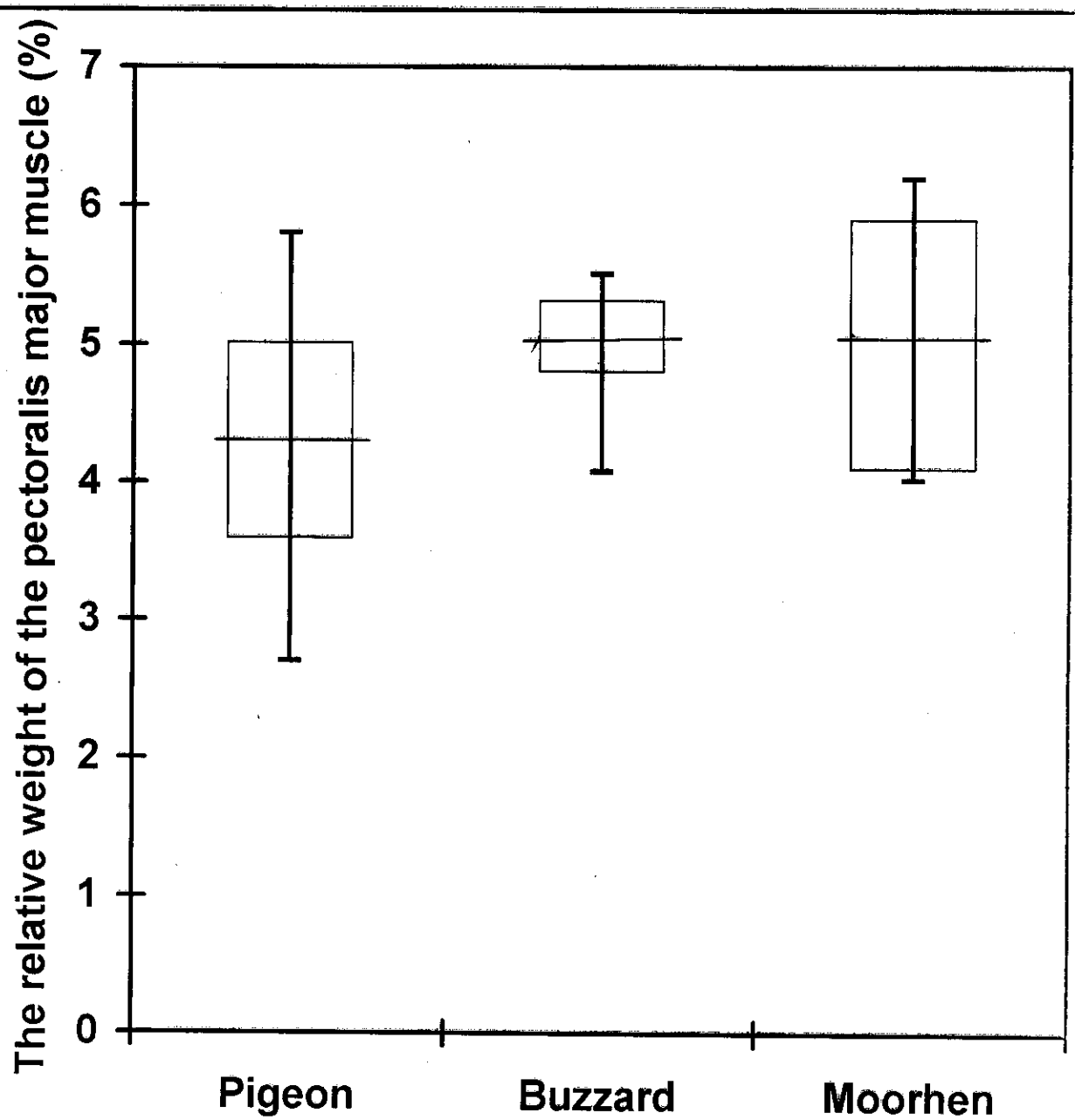


Fig (6): The relative weight of the pectoralis major muscle in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

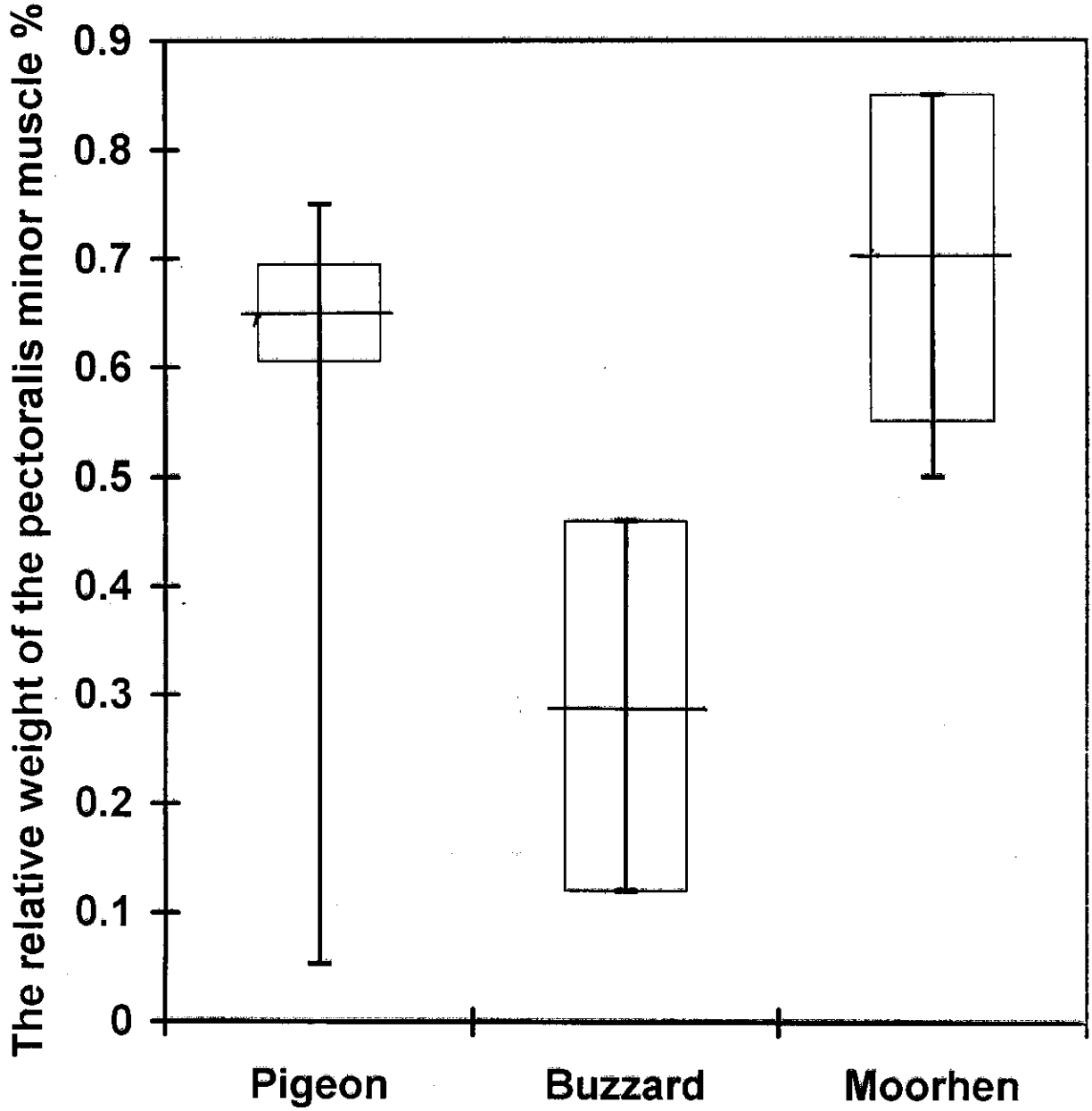


Fig (7): The relative weight of the pectoralis minor muscle in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen *(Gallinula chloropus*).

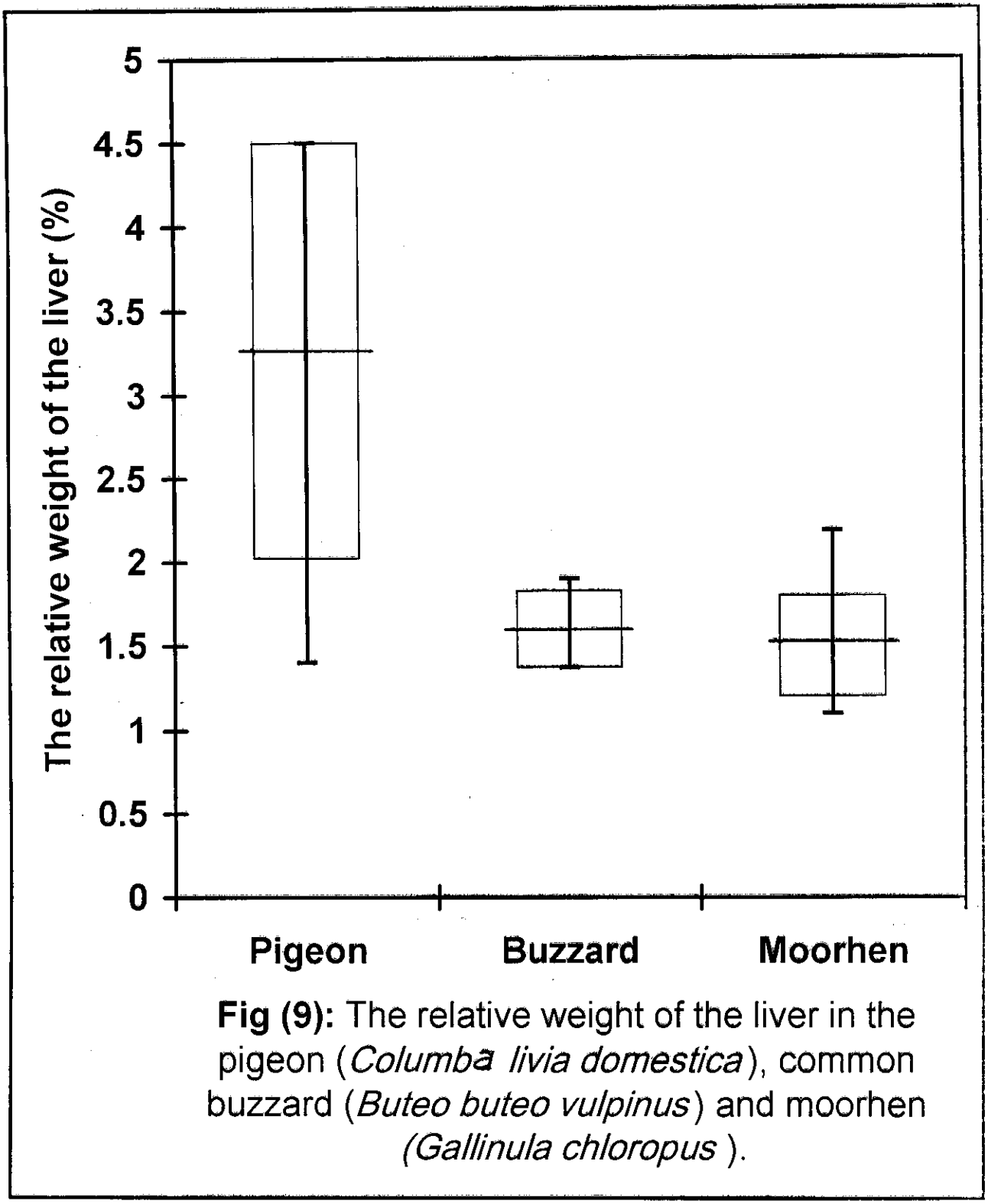


Fig (9): The relative weight of the liver in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen *(Gallinula chloropus*).

there was nonsignificant difference between those of the pigeon and moorhen (Table 1 and Fig. 10).

(11) The relative weight of the kidney

The relative weight of the kidney to the total body weight of pigeon showed nonsignificant difference with those of the buzzard and moorhen, and that of the buzzard showed nonsignificant difference with that of moorhen (Table 1 and Fig. 11).

Part II: Hematological parameters and respiratory functions of blood of the three studied birds.

a- Hematological Parameters

(1) Erythrocytes count (RBCs)

Red blood cell count of pigeon was significantly higher at ($P<0.01$) than that of buzzard and moorhen respectively. Also, erythrocyte count of moorhen was significantly higher at ($P<0.01$) than buzzard (Fig. 12 and Table 2) .

(2) Hemoglobin content (Hb):-

Hemoglobin content of pigeon was significantly higher at ($P<0.01$) than buzzard and moorhen (Table 2 and Fig. 13) illustrates that pigeon had a significant Hb content ($P<0.01$) than the buzzard and moorhen. Nonsignificant difference between the buzzard and moorhen.

Table (2): Some hematological parameters of pigeon *(Columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and the moorhen *(Gallinula chloropus)*

Parameter	Pigeon			Buzzard			Moorhen		
	M ± SD	Range		M ±SD	Range		M ±SD	Range	
RBCs (x $10^6/mm^3$)	3.50 ± 0.3	3.03 - 4.00	$^{++}\alpha$	2.300 ± 0.20	2.05 - 2.5	$^{++}\beta$	2.60 ± 0.2	2.30 - 2.90	^{++}c
Hb (g/dl)	14.70 ± 1.6	12.40 - 16.90	$^{++}\alpha$	11.400 ± 1.20	8.60 - 14.1	$^{++}\beta$	12.30 ± 0.8	8.80 - 13.40	c
Hct (%)	47.00 ± 5.3	39.00 - 52.00	$^{++}\alpha$	37.000 ± 5.60	32.00 - 46.0	$^{++}\beta$	40.20 ± 6.2	32.00 - 49.00	c
MCV(μ^3)	131.10 ± 2.3	128.10 -133.30	$^{++}\alpha$	144.300 ± 6.00	136.60 - 156.0	$^{++}\beta$	141.30 ± 6.1	131.10 - 151.00	c
MCH (pg)	40.80 ± 0.4	40.40 - 41.50	$^{++}\alpha$	42.600 ± 1.50	40.30 - 44.5	$^{++}\beta$	41.60 ± 0.8	40.50 - 42.90	c
MCHC (%)	30.90 ± 0.5	30.10 - 31.30	$^{++}\alpha$	27.100 ± 2.00	23.90 - 29.5	β	31.70 ± 1.5	29.70 - 34.70	^{++}c

M = Mean of 7 measurements

SD = standard deviation

α = Relation between pigeon and common buzzard

β = Relation between pigeon and moorhen

c =Relation between common buzzard and moorhen

\+ = Significant difference at $P < 0.05$ (for t test)

++ = Significant difference at $P < 0.01$ (for t test)

+++= Significant difference at $P < 0.001$ (for t test)

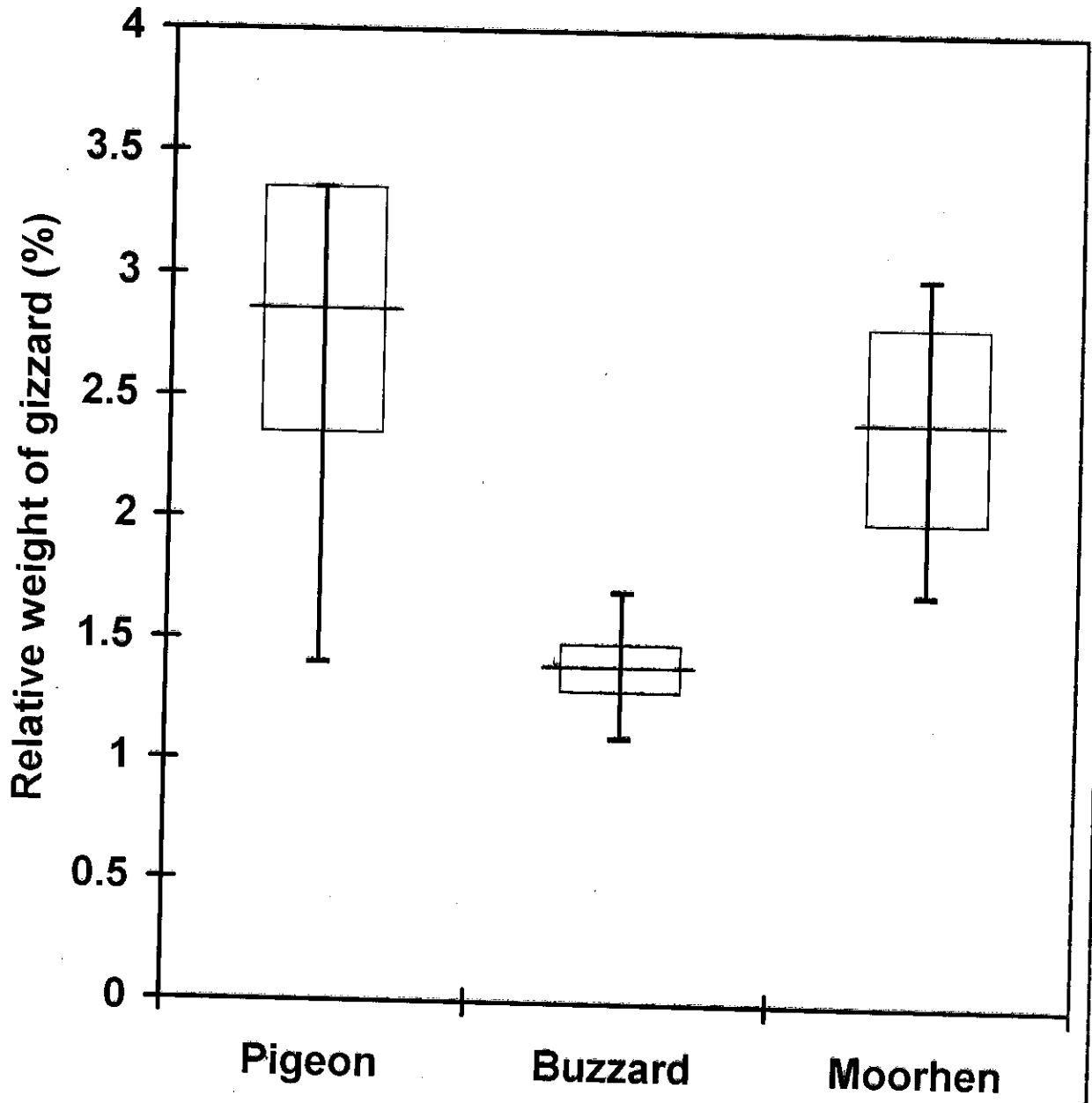


Fig (10): The relative weight of gizzard in the pigeon (*Columbà livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

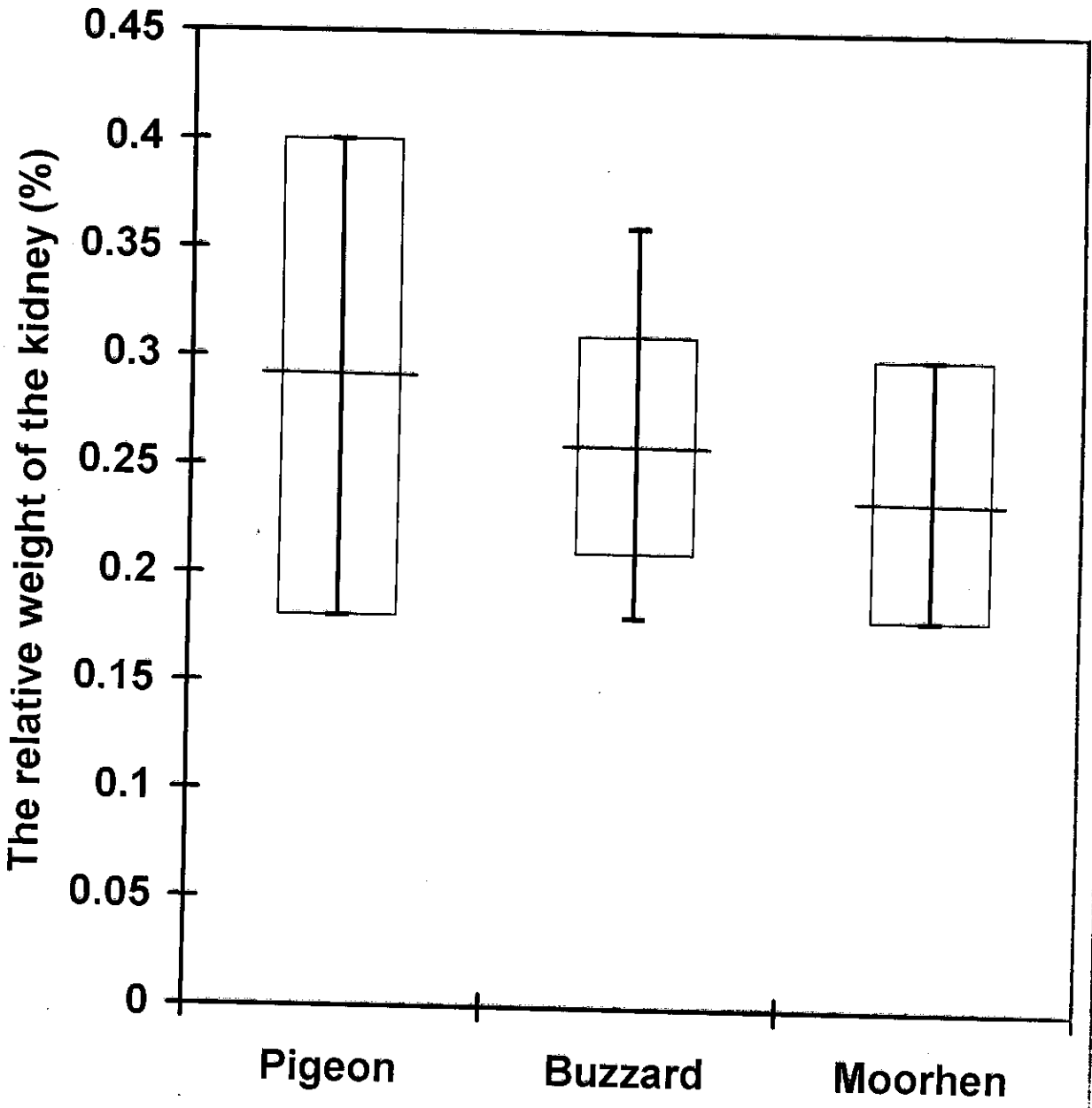


Fig (11): The relative weight of the kidney in the (*Columbâ livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

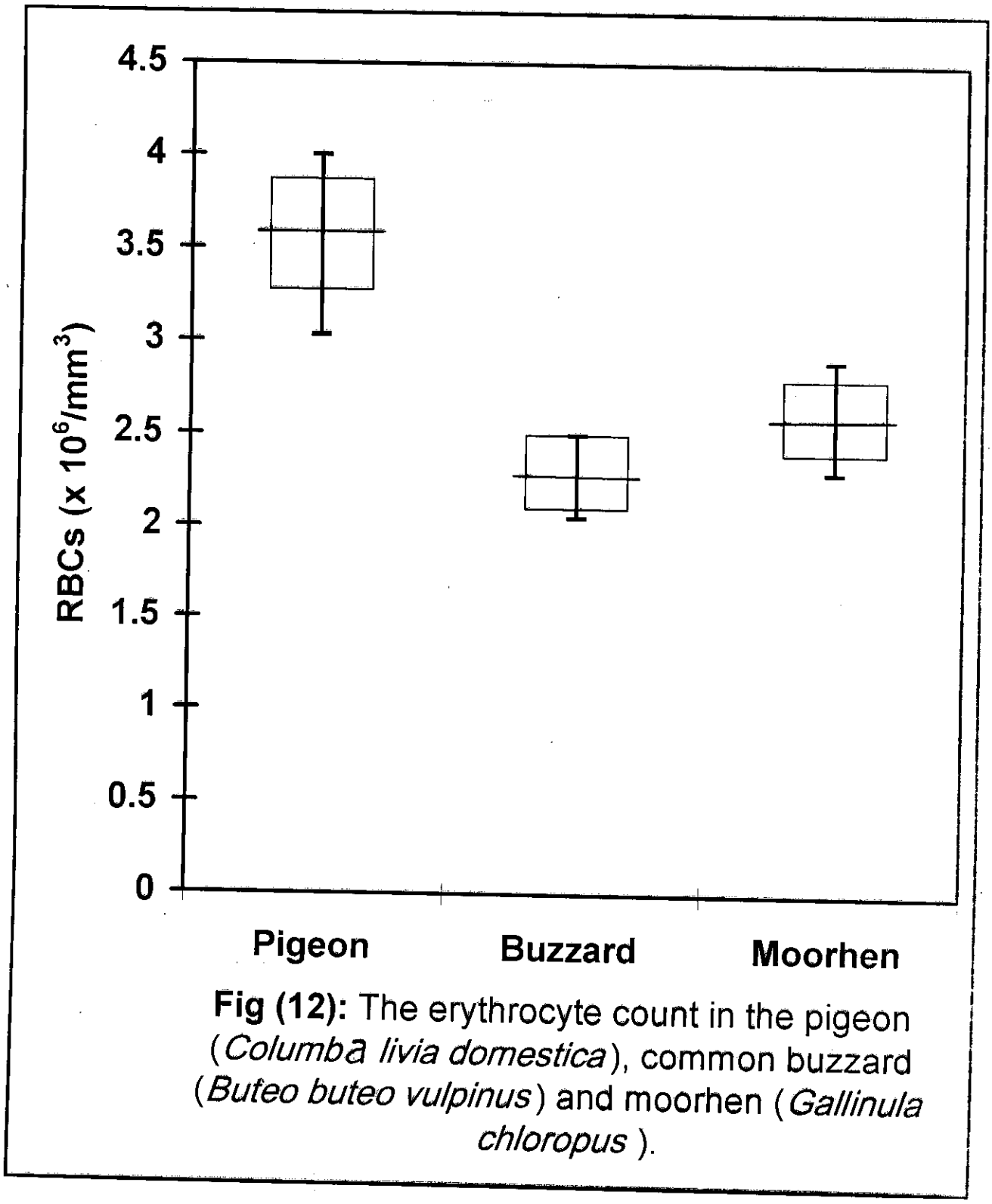


Fig (12): The erythrocyte count in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

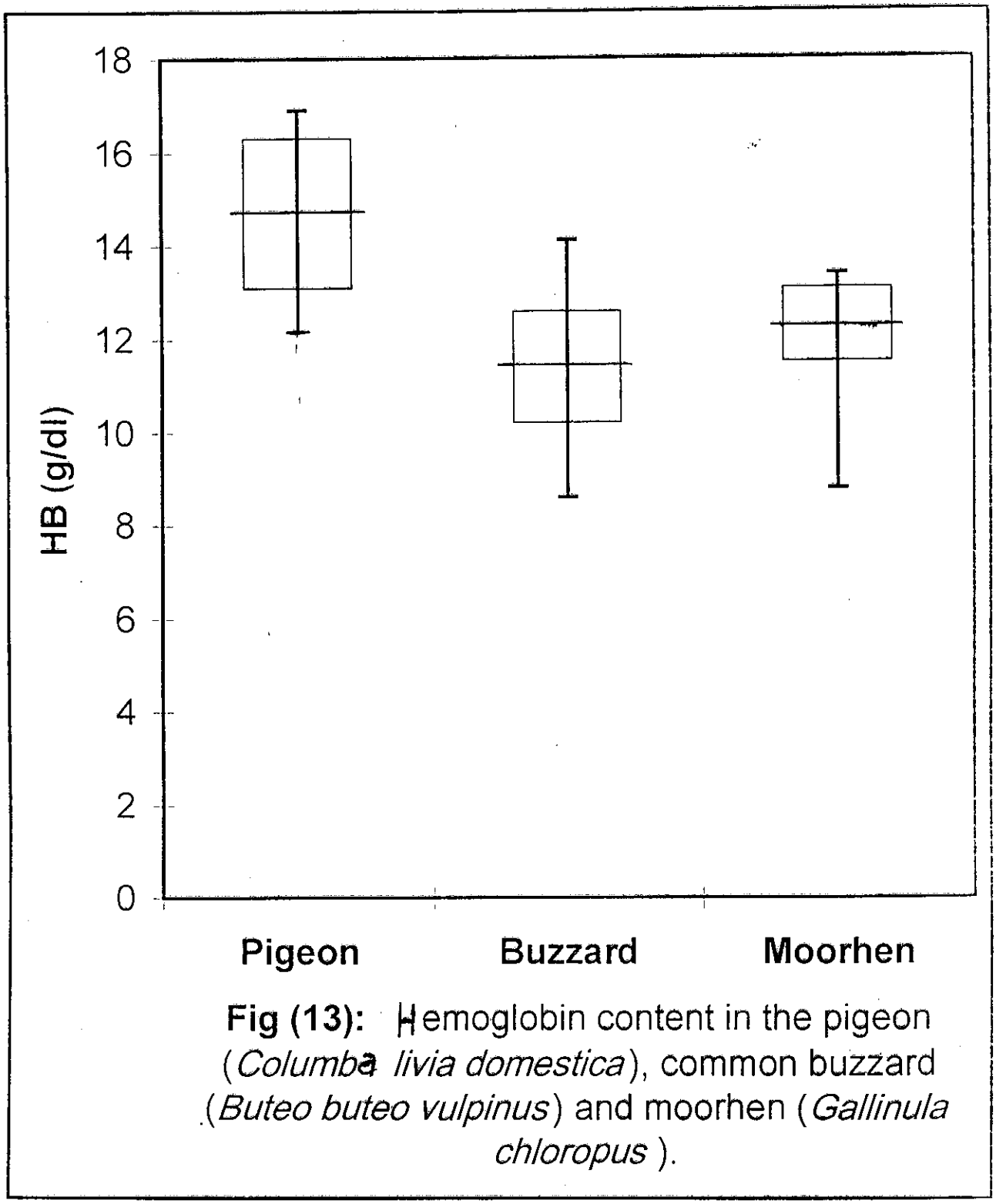


Fig (13): Hemoglobin content in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

(3) Hematocrit value (Hct)

Hematocrit value of the pigeon was higher than the buzzard and moorhen ($p<0.01$) (Table 2 and Fig. 14). This illustrated that the pigeon was significantly higher than the buzzard ($p<0.01$). The moorhen was nonsignificantly different as compared to pigeon and buzzard .

(4) Mean corpuscular volume (MCV)

MCV value of buzzard was higher than that of the pigeon and moorhen ($P<0.01$) (Table 2&Fig. 15). This illustrates that the buzzard was significantly higher than the pigeon ($P<0.01$). Also the moorhen was significantly higher than pigeon ($P<0.01$) while nonsignificant difference between the buzzard and moorhen.

(5) Mean Corpuscular hemoglobin (MCH)

MCH value of the buzzard was significantly higher ($P<0.01$) than that of the pigeon and moorhen ($p<0.01$) (Table 2 and Fig 16). This illustrates that the buzzard was significantly higher than the pigeon ($p<0.01$). The moorhen was significantly higher than the pigeon. Nonsignificant difference between the buzzard and moorhent.

(6) Mean corpuscular hemoglobin concentration (MCHC)

MCHC of the moorhen was significantly higher at ($P<0.01$) than that of the pigeon and buzzard (Fig. 17 and Table2) illustrates that the buzzard was significantly lower at ($P<0.01$) than that of the

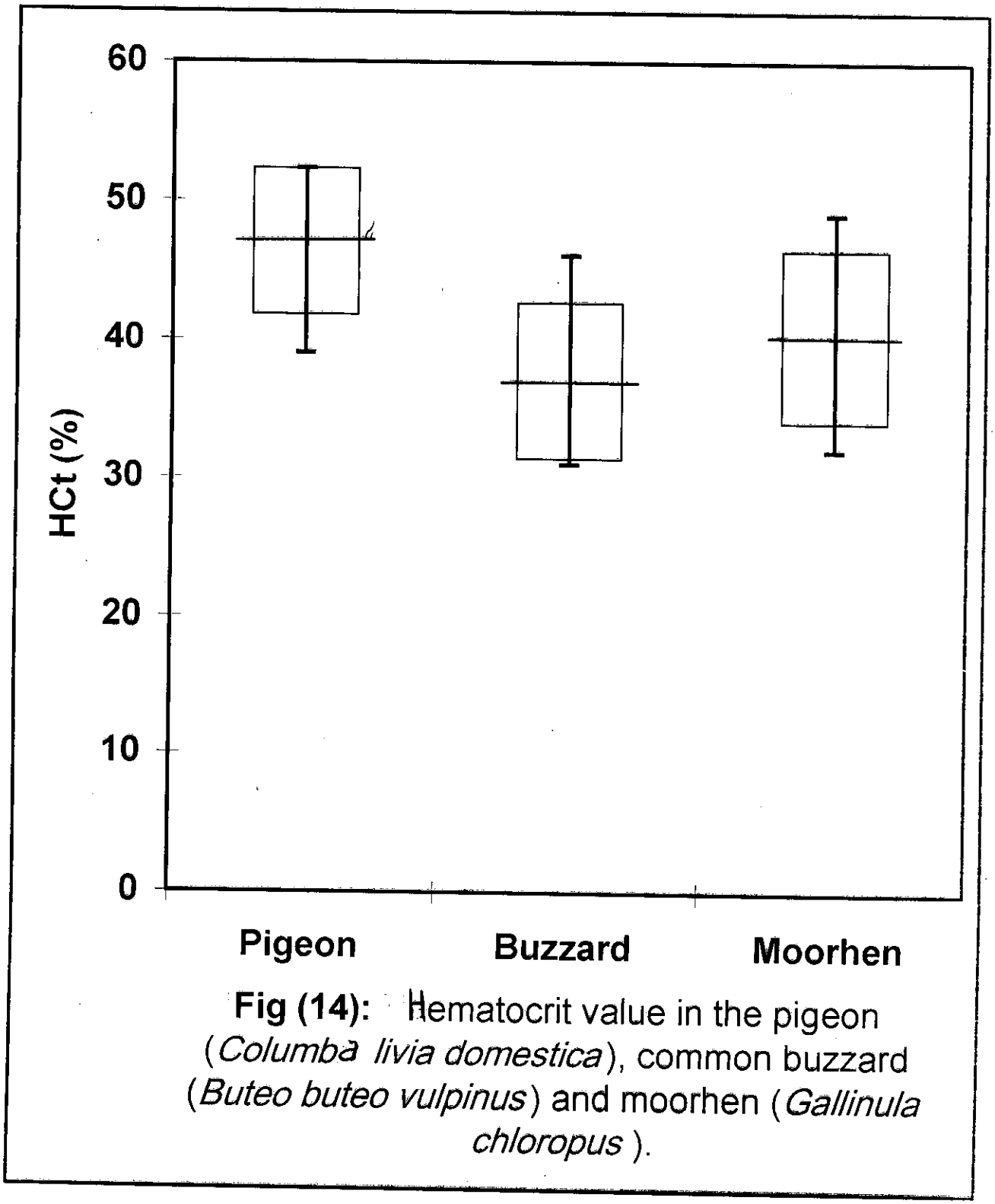


Fig (14): Hematocrit value in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

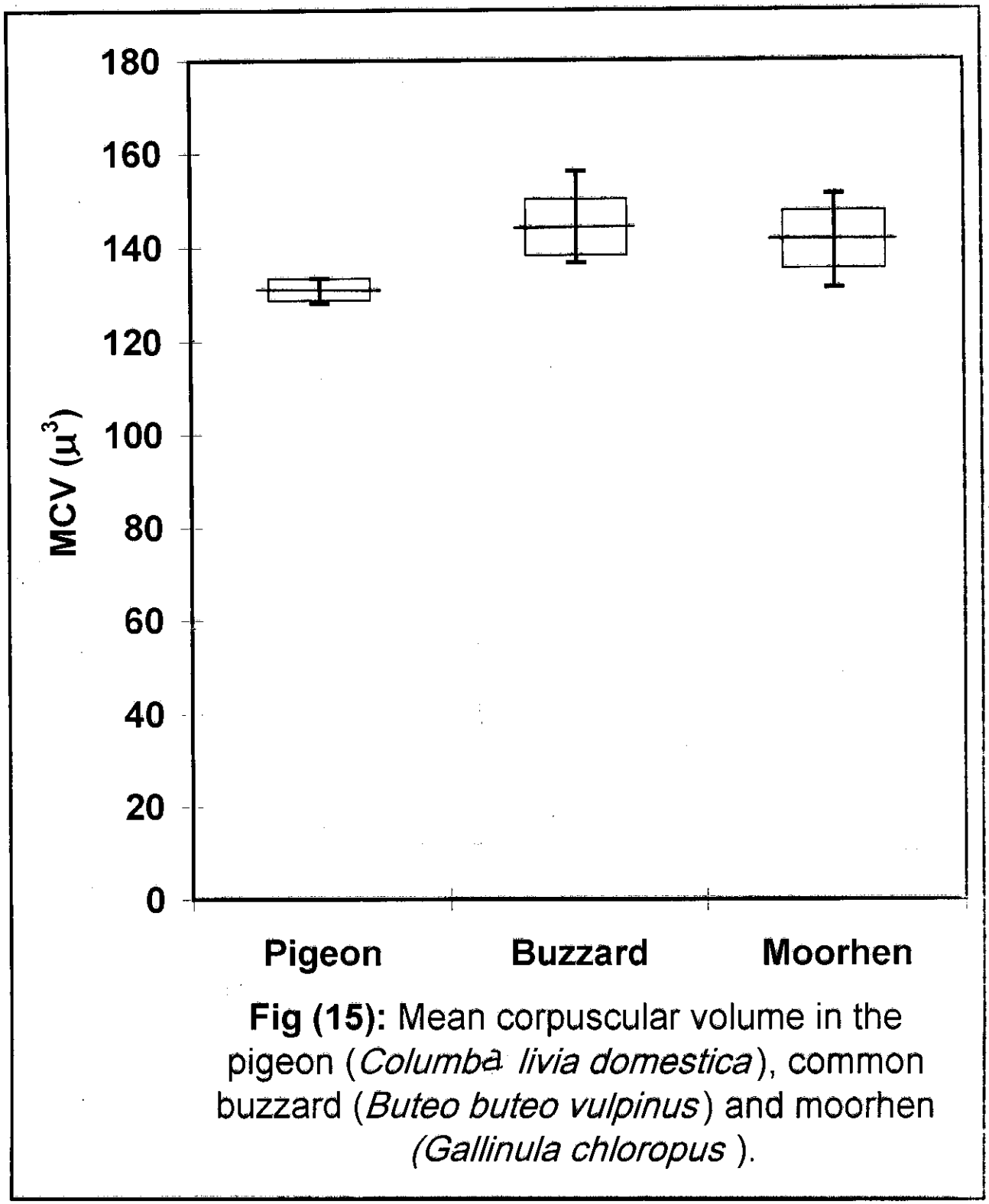


Fig (15): Mean corpuscular volume in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen *(Gallinula chloropus*).

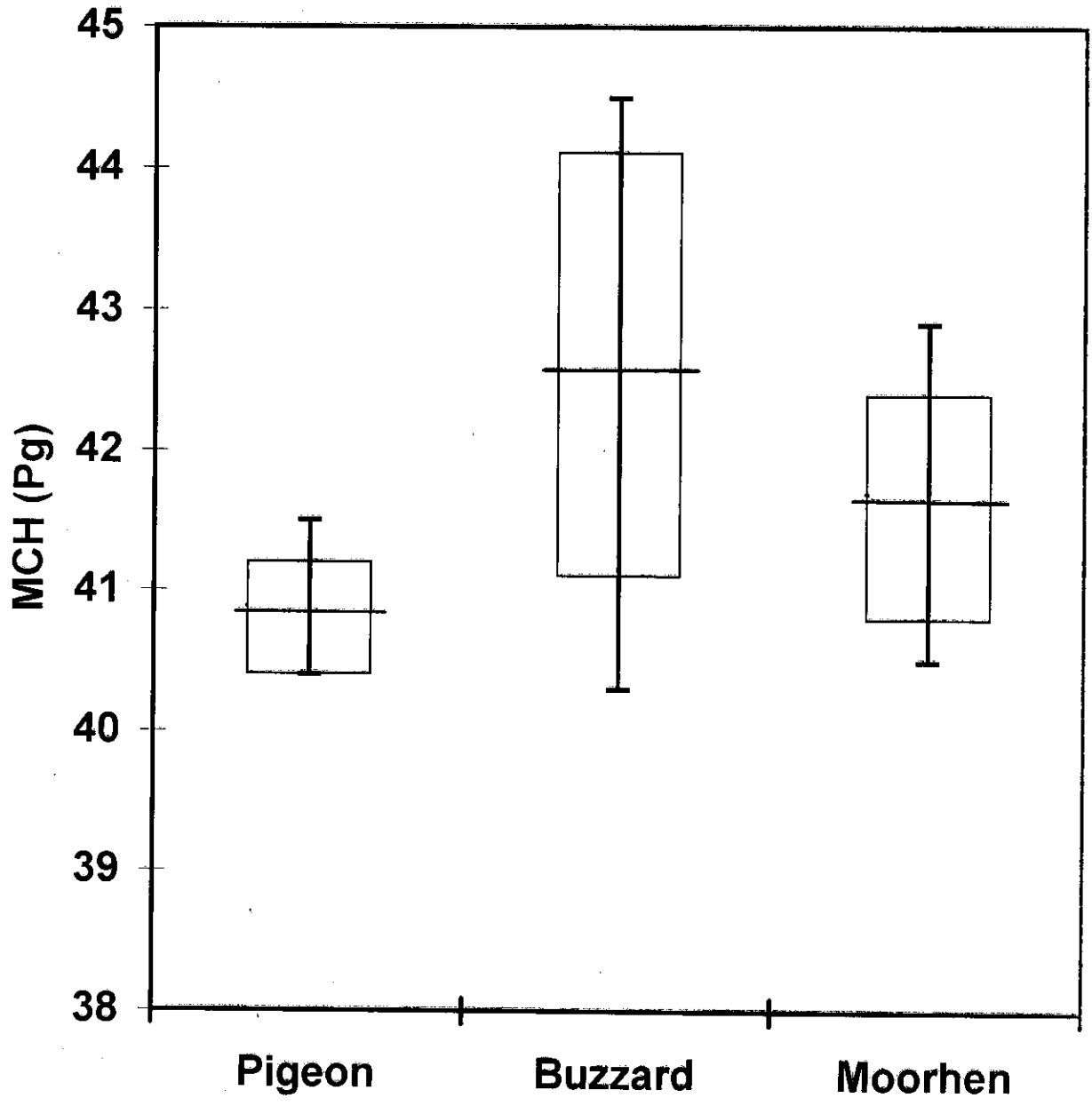


Fig (16): Mean corpusclar hemoglobin in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

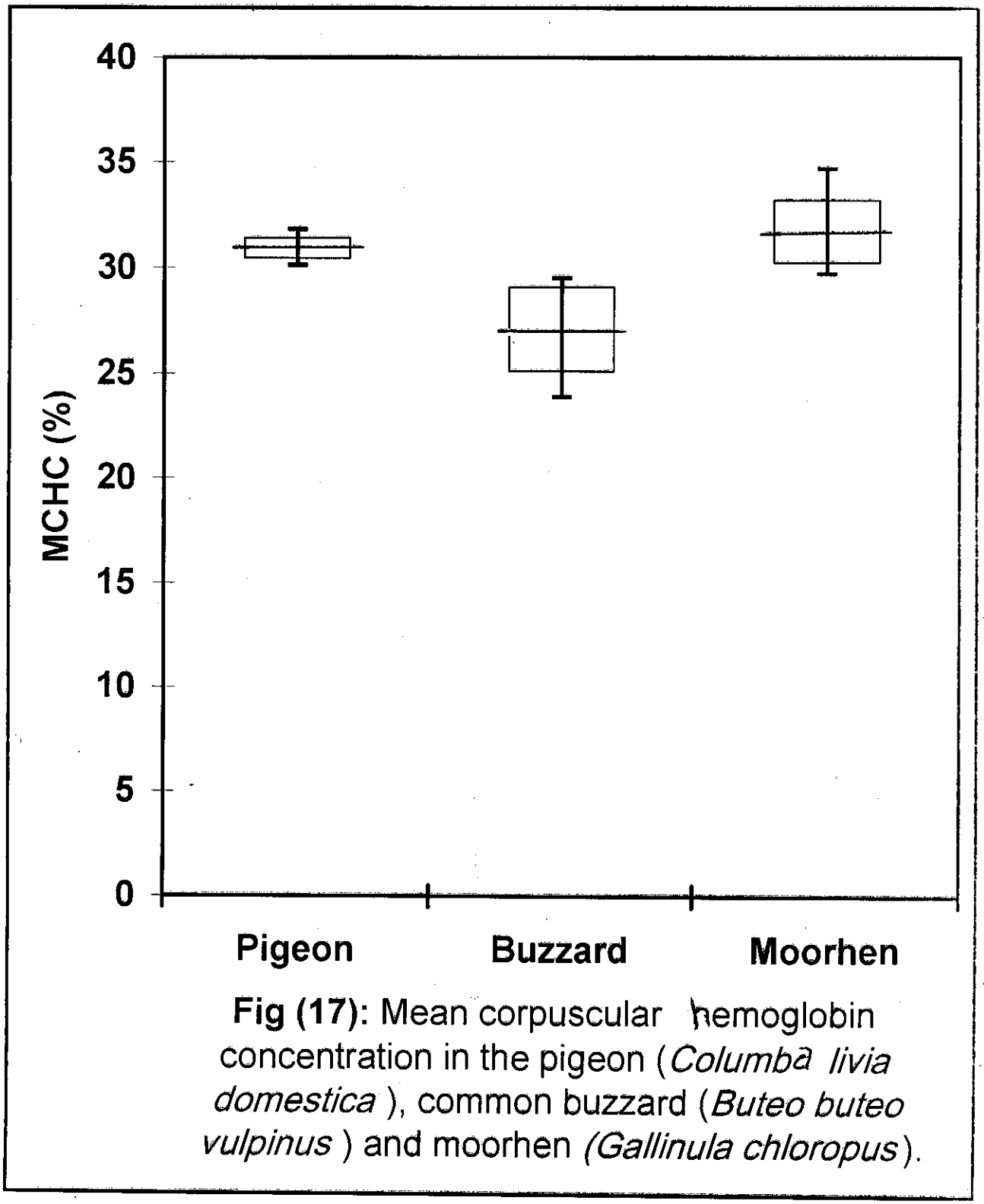


Fig (17): Mean corpuscular hemoglobin concentration in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen *(Gallinula chloropus*).

pigeon and moorhen , nonsignificant difference between the pigeon and moorhen.

b- Respiratory Functions Of Blood

Effect Of Flight On Respiratory Functions Of Blood Of Three Studied Birds

1-Blood Gases:

Table. (3) and figs. (18,19&20) represented parameters of partial pressure of blood gases for the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and the moorhen (*Gallinula chloropus*).

Arterial blood oxygen partial pressure (PaO_2) of the common buzzard was found to be significantly higher ($p < 0.01$) than that of the pigeon, which was found to be nonsignificantly higher than that of the moorhen. Also, it was significantly higher ($P<0.01$) than that of the moorhen (Table 3 & Fig. 18).

Arterial blood partial pressure of carbon dioxide ($P_a CO_2$) of the common buzzard and moorhen were non significantly high as compared to that of pigeon and P_aCO_2 of the common buzzard was also non significantly high as compared to that of the moorhen (Table 3 & Fig. 20).

Percentage O_2 saturation ($\%O_{2)}$ sat) of arterial blood of the pigeon was significantly higher ($P<0.05$) than that of the common buzzard. It was significantly high ($P<0.001$) for the pigeon as compared to that of the moorhen, while that of the common buzzard was non significantly high as compared to that of the moorhen (Table 3 & Fig. 19).

Table (3):Blood gases (mean ± standard deviation) for pigeon *(Columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and the moorhen *(Gallinula chloropus)*

Parameters		Pigeon		Buzzard		Moorhen		" F "
PO_2 (mmHg)	a	65.9 ± 6.4	α^{++}	82.60 ± 8.9	β^{Ns}	61.6 ± 9.4	c^{++}	* * *
	v	48.0 ± 7.7	α^{+}	55.05 ± 6.1	β^{+}	37.4 ± 8.5	c^{++}	* * *
	% a-v	34.3 ± 3.0	α^{+}	38.70 ± 9.1	β^{++}	25.9 ± 5.9	c^{++}	* * *
% O_2 Sat	a	95.2 ± 2.7	α^{+}	86.70 ± 6.30	β^{+++}	82.7 ± 7.4	c^{Ns}	* * *
	v	64.6 ± 6.9	α^{++}	51.30 ± 7.26	β^{+}	50.5 ± 2.4	c^{NS}	* * *
	% a-v	25.9 ± 5.9	α^{Ns}	31.21 ± 9.30	β^{+}	19.3 ± 6.5	c^{+}	* *
PCO_2 (mm Hg)	a	26.6 ± 5.3	α^{Ns}	32.3 ± 9.9	β^{Ns}	29.0 ± 4.93	c^{Ns}	Ns
	v	41.4 ± 4.5	α^{++}	59.0 ± 8.4	β^{++}	58.6 ± 8.50	c^{Ns}	* * *
	% a-v	-33.0 ± 2.0	α^{+}	-13.3 ± 7.5	β^{Ns}	-35.4 ± 7.10	c^{+++}	* * *

a = arterial blood v = venous blood
a – v= arterio – venous difference
sat = saturation
Ns = Non significant difference
* = Significant difference at $P < 0.05$ (for F test)
** = Significant difference at $P < 0.01$ (for F test)
*** = Significant difference at $P < 0.001$ (for F test)
α = Relation between pigeon and common buzzard
β = Relation between pigeon and moorhen
c = Relation between common buzzard and moorhen
+ = Significant difference at $P < 0.05$ (for t test)
++ = Significant difference at $P < 0.01$ (for t test)
+++= Significant difference at $P<0.001$ (for t test)

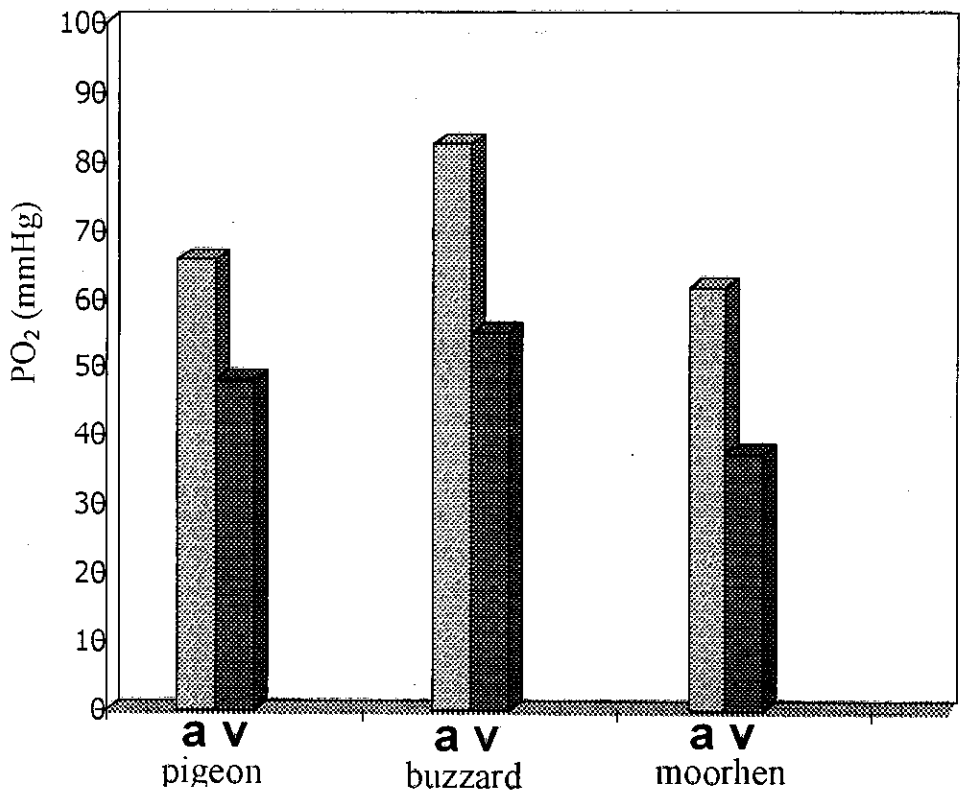


Fig (18) : Arterial (a) and venous (v) blood oxygen partial pressures (PO_2 in mmHg) for the pigeon *(columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and moorhen *(Gallinula chloropus)*.

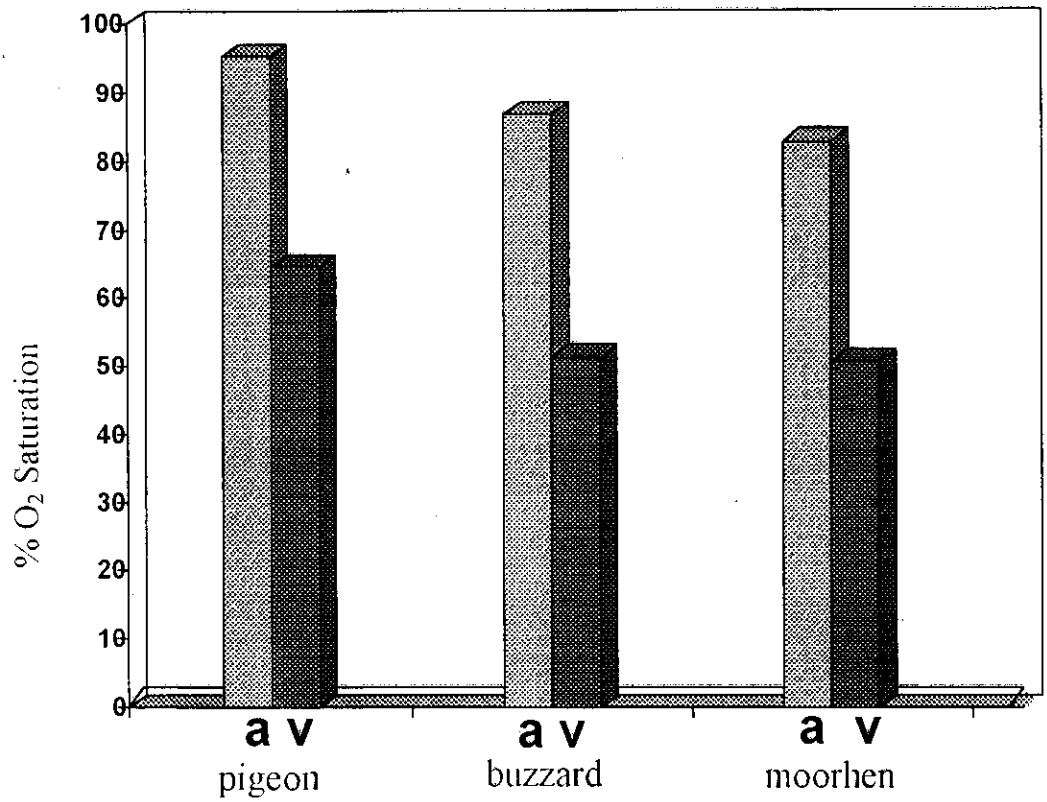


Fig (19): Arterial (a) and venous (v) blood % O_2 Saturation for the pigeon *(columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and moorhen *(Gallinula chloropus)*.

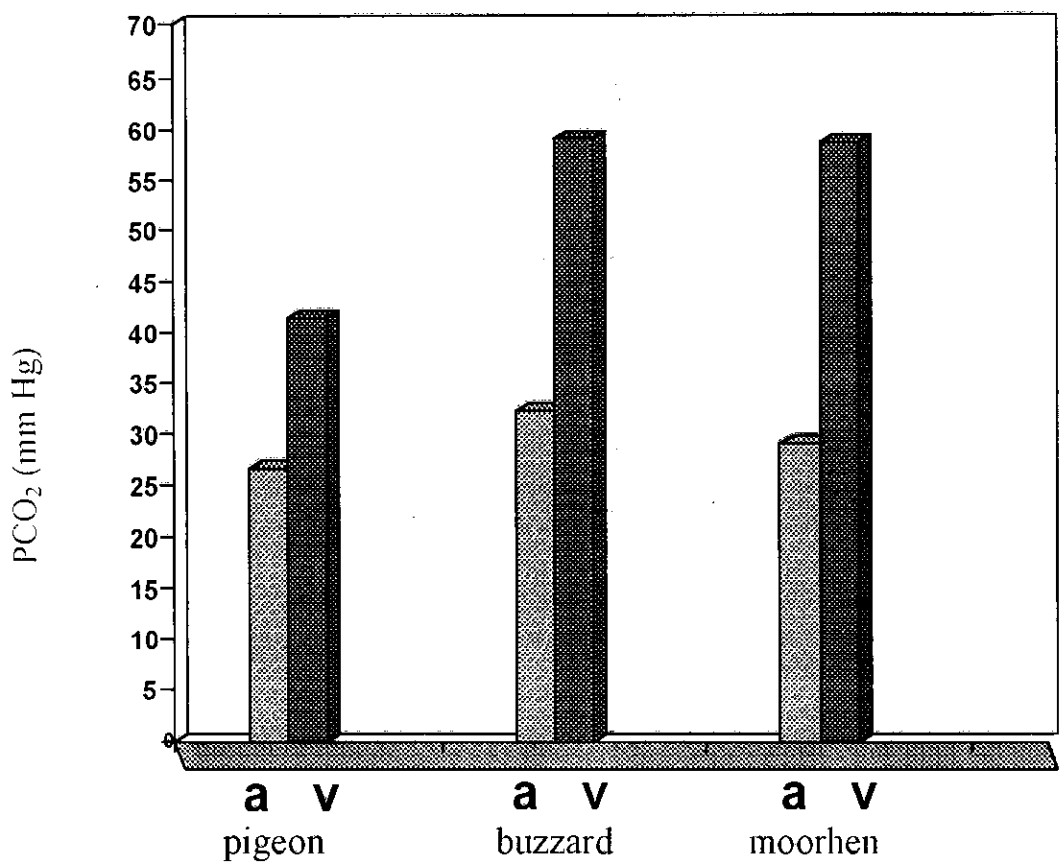


Fig (20): Arterial (a) and venous (v) blood carbon dioxide partial pressures (PCO_2 in mmHg) for the pigeon *(columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and moorhen *(Gallinula chloropus)*.

Venous blood oxygen partial pressure (P_vO_2) of the common buzzard was significantly higher than those of the pigeon and moorhen ($P< 0.05$) and ($P<0.01$) respectively. P_vO_2 of the pigeon was significantly higher ($P<0.05$) than that of the moorhen (Table 3 &Fig. 18). The arterio-venous PO_2 difference ($P_{a-v}O_2$) of the common buzzard was nonsignificantly higher than that of the pigeon. ($P_{a-v}O_2$) of the moorhen had the lowest value compared to those of the pigeon and common buzzard. ($P_{a-v}O_2$) of the pigeon was significantly higher ($P<0.01$) than that of the moorhen. ($P_{a-v}O_2$) of the common buzzard was significantly higher ($P< 0.05$) than that of the moorhen.

Analysis of the variance (F-test) for PO_2 indicated that P_aO_2 and ($P_{a-v}O_2$) values were significantly different ($p<0.001$) for between the three birds. The common buzzard has the highest value for P_aO_2 and the moorhen has the lowest value. For the P_vO_2 and ($P_{a-v}O_2$), also the common buzzard has the highest value and the moorhen has the lowest value.

Venous blood carbon dioxide partial pressure (P_vCo_2) of both the common buzzard and moorhen were significantly high ($p< 0.01$) as compared to that of the pigeon, while P_vCo_2 of the common buzzard showed nonsignificant difference from that of the moorhen (Table 3 & Fig. 20).

Venous blood % O_2 sat of the pigeon was significantly high at ($P<0.01$) and ($P<0.05$) as compared to that of the common buzzard and moorhen respectively, while venous blood % O_2 sat of the common buzzard was non significantly high ($P<0.05$) as compared to that of the moorhen. The % arterio-venous difference (% a-v) of

% O_2 sat of the common buzzard (Table 3) was nonsignificantly and significantly high ($P<0.05$) as compared to that of the pigeon and moorhen respectively.

Arterio-venousPCO_2 difference ($P_{a-v}CO_2$) of the common buzzard was significantly higher ($P<0.05$) than that of the pigeon. ($P_{a-v}CO_2$) of the common buzzard and moorhen were significantly higher ($P<0.05$) than that of the pigeon, while that of the common buzzard was significantly higher ($P< 0.001$) as compared to that of the moorhen (Table 3). The pigeon was significantly high ($p<0.05$) as compared to that of the moorhen.

Analysis of the variance (F test) indicated that P_aCO_2 values were nonsignificantly different for the three studied bird species. P_vCO_2 values were significantly different ($P<0.001$) for the three bird species. The common buzzard have the highest value and the pigeon has the lowest value. ($P_{a-v}O_2$) was significantly different ($P<0.001$) for the three bird species. The common buzzard has the highest value and the moorhen has the lowest value (Table 3).

Analysis of the variance (F test) showed that % O_2 sat of both arterial and venous blood were significantly different ($P<0.001$) in the three bird species. The pigeon has the highest values and the moorhen has the lowest values. Also (% a-v) of the % O_2 sat showed significant differences ($P<0.01$) between the three bird species. The common buzzard has the highest value and the moorhen has the lowest value (Table 3).

2-Blood Acid – Base Status

Table. (4) and figs. (21,22,23&24) represent blood acid-base status parameters for the pigeon (*Columba livia domestica*), common buzzard *(Buteo buteo vulpinus)* and the moorhen *(Gallinula chloropus)*. The arterial blood pH of the pigeon was significantly high ($P< 0.05$) as compared to that of the common buzzard, while that of the moorhen was nonsignificantly high as compared to that of the pigeon. Also arterial blood pH of the common buzzard was nonsignificantly high as compared to that of the moorhen, (Table 4 & Fig. 21).

Arterial blood bicarbonate (HCO_3^-) concentration of the pigeon and moorhen were significantly high ($P<0.01$) as compared to that of the common buzzard, while that of the moorhen was non significantly high as compared to that of the pigeon (Table 4 & Fig. 22).

Arterial blood (TCO_2) of the pigeon was significantly at ($P<0.05$) and nonsignificantly high as compared to those of the common buzzard and the moorhen respectively, while that of the moorhen was significantly high ($P<0.05$) as compared to that of the common buzzard (Table 4 & Fig.23).

Arterial blood base excess (BE) of the pigeon was non significantly and significantly high ($P<0.05$) as compared to those of the common buzzard and moorhen respectively, while that of the moorhen was non significantly higher than that of the common buzzard (Table 4 & Fig. 24).

Table (4) : Blood acid – base status parameters (mean ± standard deviation) for pigeon *(Columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and the moorhen *(Gallinula chloropus)*

Parameters		Pigeon		Common buzzard		Moorhen		" F "
pH (Unit)	a	7.25 ± 0.10	α^{++}	7.21 ± 0.10	β^{Ns}	7.360 ± 0.01	c^{Ns}	Ns
	v	7.23 ± 0.10	α^{Ns}	7.22 ± 0.10	β^{+}	7.330 ± 0.09	c^{+}	*
	%a-v	-0.16 ± 0.08	α^{+}	-0.02 ± 0.13	β^{++}	0.003 ± 0.01	c^{Ns}	* * *
HCO_3^- (mmol/l)	a	14.2 ± 1.6	α^{+}	16.5 ± 1.7	β^{Ns}	15.7 ± 1.6	c^{Ns}	* * *
	v	25.5 ± 3.5	α^{++}	21.9 ± 3.4	β^{Ns}	23.7 ± 1.1	c^{NS}	Ns
	% a-v	–23.5 ± 4.6	α^{Ns}	- 9.9 ± 2.1	β^{+}	- 7.0 ± 1.3	c^{+}	* * *
TCO_2 (mmol/l)	a	22.7 ± 6.0	α+	12.8 ± 0.6	β^{Ns}	17.5 ± 1.6	c^{+}	* * *
	v	25.4 ±5.1	α^{Ns}	24.7 ± 4.8	β^{Ns}	25.0 ± 0.2	c^{Ns}	Ns
	% a-v	-30.0 ± 7.3	α^{+++}	-12.1 ± 3.7	β^{+}	-7.4 ± 1.4	c^{Ns}	* * *
BE (mmol/l)	a	-2.6 ± 0.900	α^{Ns}	-10.1 ± 2.2	β+	-8.0 ± 4.5	c^{Ns}	* *
	v	- 2.6 ±1.600	α^{NS}	-5.4 ± 3.5	β+	-7.4 ± 3.6	c^{Ns}	Ns
	% a-v	0.4 ± 0.001	α^{Ns}	-6.0 ± 2.3	β^{Ns}	-2.2 ± 1.1	c^{Ns}	Ns

a = arterial blood v = venous blood
a – v = arterio – venous difference
T= total CO_2, BE = base excess
Ns = Non significant difference
* = Significant difference at $P < 0.05$ (for F test)
** = Significant difference at $P < 0.01$ (for F test)
*** = Significant difference at $P < 0.001$ (for F test)
α = Relation between pigeon and common buzzard
β = Relation between pigeon and moorhen
c =Relation between common buzzard and moorhen
\+ = Significant difference at $P < 0.05$ (for t test)
++ = Significant difference at $P < 0.01$ (for t test)
+++= Significant difference at $P < 0.001$ (for t test)

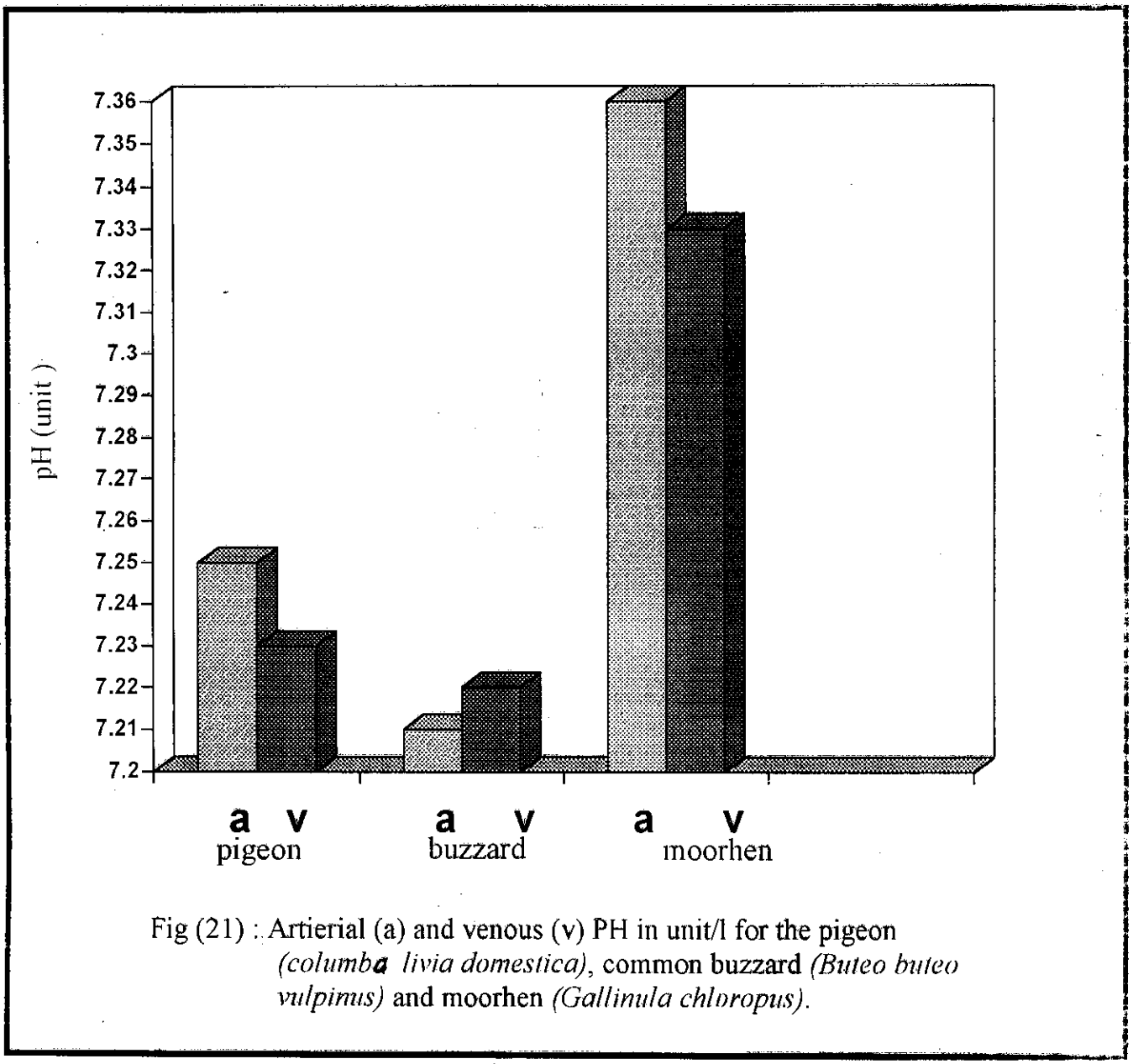


Fig (21) : Artierial (a) and venous (v) PH in unit/l for the pigeon *(columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and moorhen *(Gallinula chloropus)*.

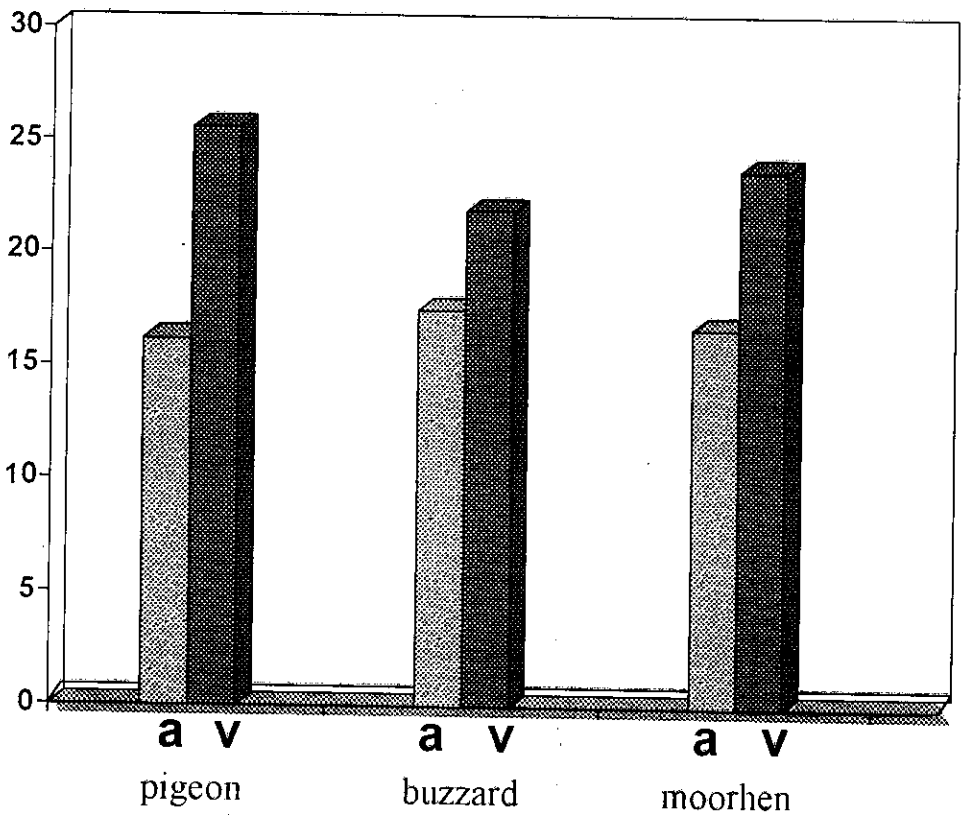


Fig (22): Arterial (a) and venous (v) blood bicarbonate concentration (HCO^-_3 in mmol/l) for the pigeon *(columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and moorhen *(Gallinula chloropus)*.

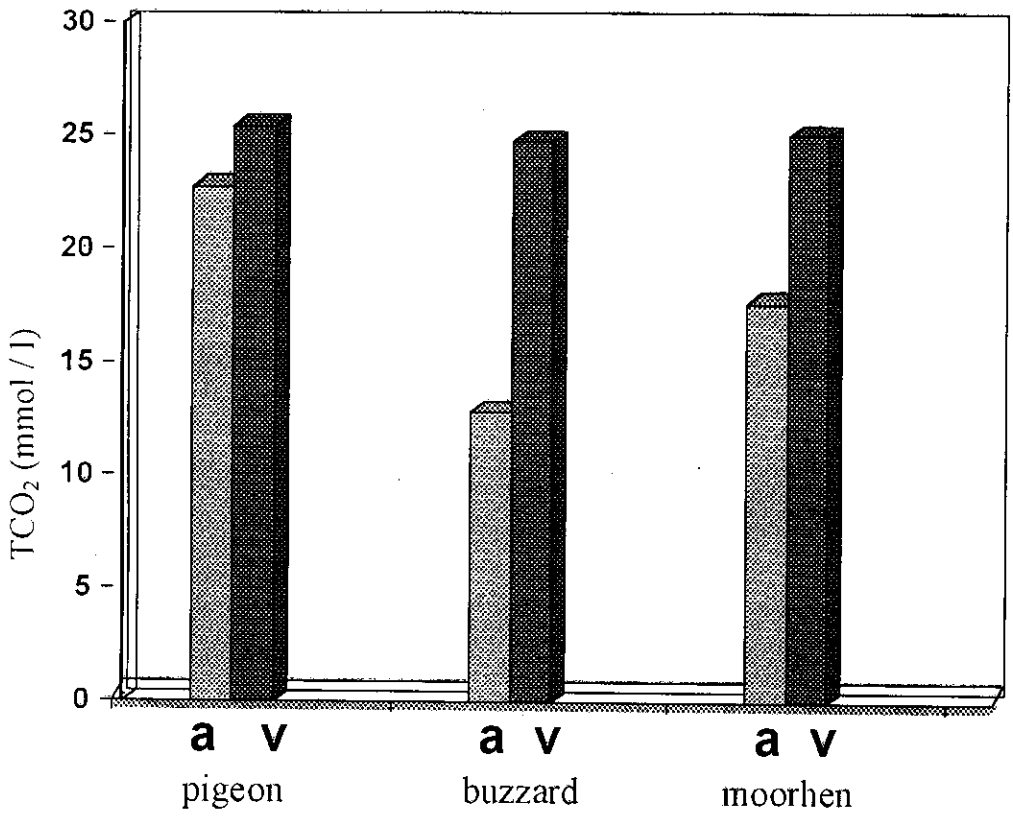


Fig (23): Arterial (a) and venous (v) blood total carbon dioxide (TCO_2 in mmol / l) for the pigeon *(columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and moorhen *(Gallinula chloropus)*.

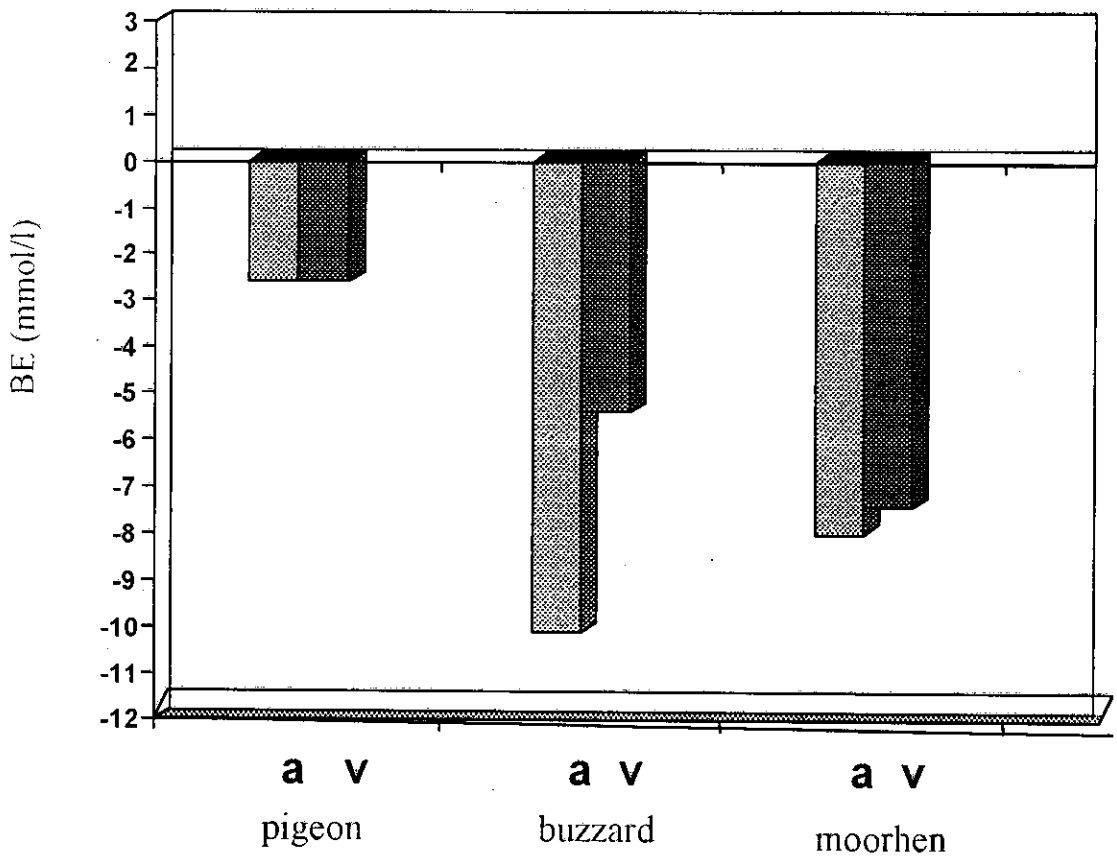
The venous blood pH was non significantly different for both the pigeon and the common buzzard. The venous blood pH of the moorhen was significantly high ($P<0.05$) as compared to those of both the pigeon and the common buzzard. (Table 4 & Fig. 21).

Venous blood HCO_3^- concentration of the pigeon and moorhen were significantly ($P<0.05$) and nonsignificantly high as compared to that of the common buzzard,"while that of the moorhen was non significantly low as compared to that of the pigeon (Table 4 and Fig. 22).

Venous blood TCO_2 of the pigeon was nonsignificantly high as compared to those of both the common buzzard and moorhen. Also, venous blood TCO_2 of the moorhen was non significantly high as compared to that of the common buzzard. (Table 4 & Fig. 23).

Venous blood BE of the pigeon was non significantly and significantly high ($P>0.05$) as compared to those of the common buzzard and moorhen respectively. It was non significantly high in the common buzzard as compared to that of the moorhen (Table 4 & Fig. 24).

The % arterio-venous difference values of pH of both the common buzzard and the moorhen were significantly high ($P<0.05$) as compared to that of the pigeon. The values for the common buzzard and the moorhen were nonsignificantly different (Table4) .The % arterio-venous difference of HCO_3^- concentration of both the common buzzard and the moorhen were significantly higher ($P<0.05$) than that of the pigeon, while that of the moorhen was significantly higher ($P< 0.05$) than that of the common buzzard (Table 4).



Fig(24): Arterial (a) and venous (v) blood base excess (BE in mmol/l) for the pigeon *(columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and moorhen *(Gallinula chloropus)*.

The arterio – venous difference of BE showed non significant difference between the there birds (Table 4)

The % arterio-venous difference value of TCO_2 of the moorhen was non significantly high as compared to that of the common buzzard. (Table 4).

Analysis of the variance (F test) indicated that the pH values of arterial blood were nonsignificantly different in the three bird species, while those of the venous blood were significantly different ($P<0.05$) in the three bird species. The % a-v values of the pH were found to be significantly different ($P<0.001$) in the three bird species, The moorhen has the highest value and the pigeon has the lowest value (Table 4).

Analysis of the variance (F-test) indicated that arterial blood TCO_2 values were significantly different at ($P<0.001$) in the three bird species. The pigeon has the highest value and the common buzzard . has the lowest value. Venous blood TCO_2 showed nonsignificantly differences in the three bird species. The % arterio –venous difference of TCO_2 showed significant differences at ($P<0.001$) between the three bird species. The moorhen has the highest value and the pigeon has the lowest value (Table 4).

Ananysis of the variance (F. test) showed that arterial blood HCO_3^- concentration was significantly different ($P<0.001$) between the three bird species. The moorhen has the highest value and the common buzzard has the lowest value. Venous blood HCO_3^- concentrations showed non significant differences between the three bird species. The % arterio-venous difference of HCO_3^-

concentrations showed significant differences ($P<0.001$) between, the three bird species. The moorhen has the highest value and the pigeon has the lowest value (Table 4).

Analysis of the variance (F test) showed that arterial blood base excess BE was significantly different ($P<0.01$) between the three bird species. The pigeon has the highest value and the common buzzard has the lowest value. Venous blood BE showed nonsignificant difference between the three bird species. The % arterio –venous difference of BE showed significant differences between the three bird species (Table 4).

3-Oxygen Equilibrium Curve OEC

The oxygen equilibrium curves (OEC) of the pigeon, common buzzard and moorhen were represented in figs. (25 , 26&27) & fig.28 and table (8) showed that the position of the OEC of the buzzard was to the right of those of pigeon and moorhen which were nearly at the same location . The blood oxygen affinities of the three bird species (P_{50} values) were non significantly different ($P_{50} = 31 \pm 0.32$, 33 ± 0.34 and 32 ± 0.35 mmHg for the pigeon, common buzzard and moorhen, respectively).

Table (5): Blood oxygen half saturation pressure (P_{50}) (mean ± standard deviation) and Hill's n value for pigeon *(columbia livia domestica)* common buzzard (*Buteo buteo vulpinus*) and the moorhen *(Gallinula chloropus)*

Parameter	Pigeon	Buzzard	Moorhen
P_{50} (mmHg)	31 ± 0.32^{A}	33 ± 0.34^{A}	32 ± 0.35^{A}
n	1.7	1.54	2

Same letters indicate non significant difference.

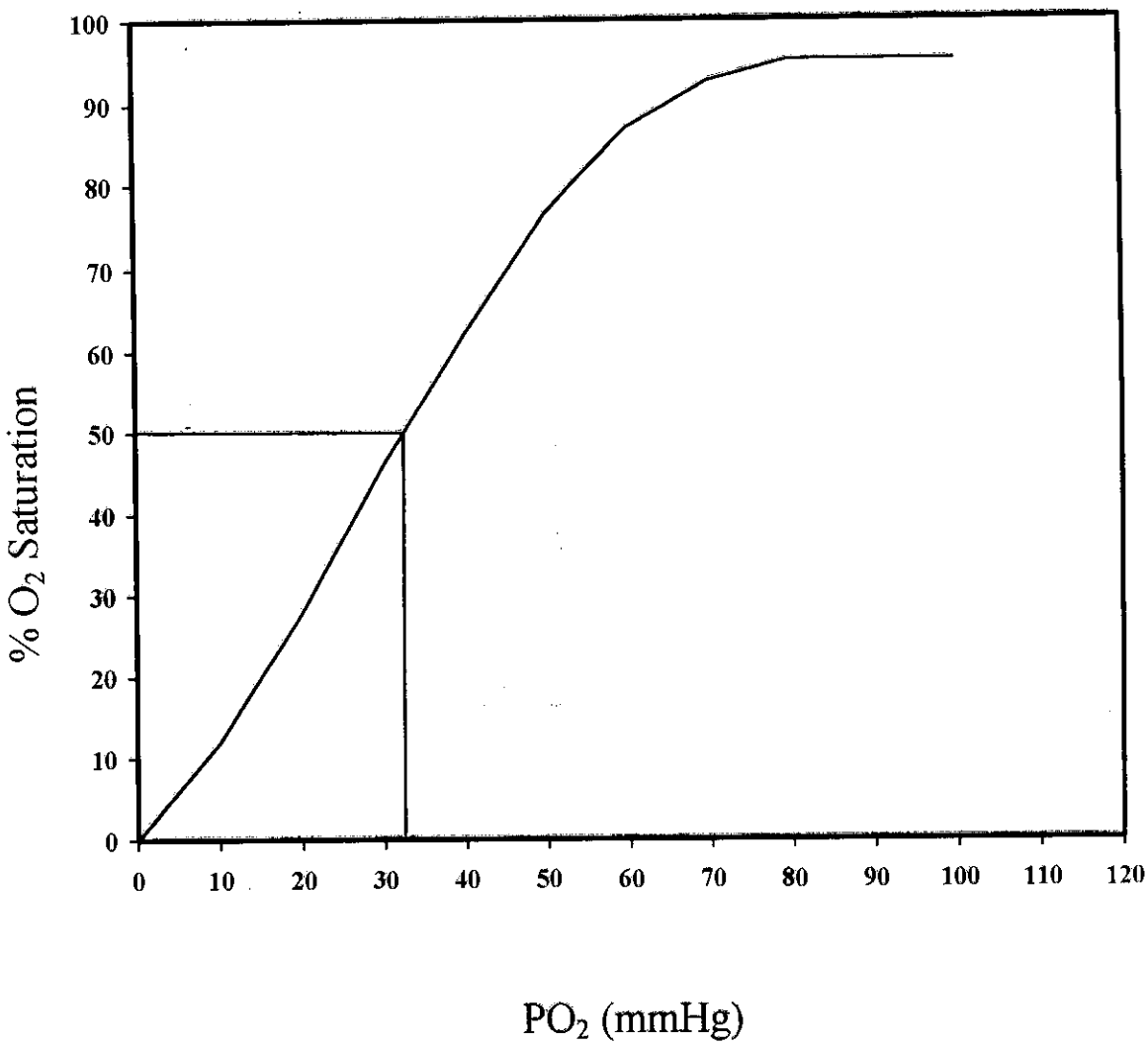


Fig. (25): Oxygen equilibrium curve of the pigeon *(columba livia domestica)*

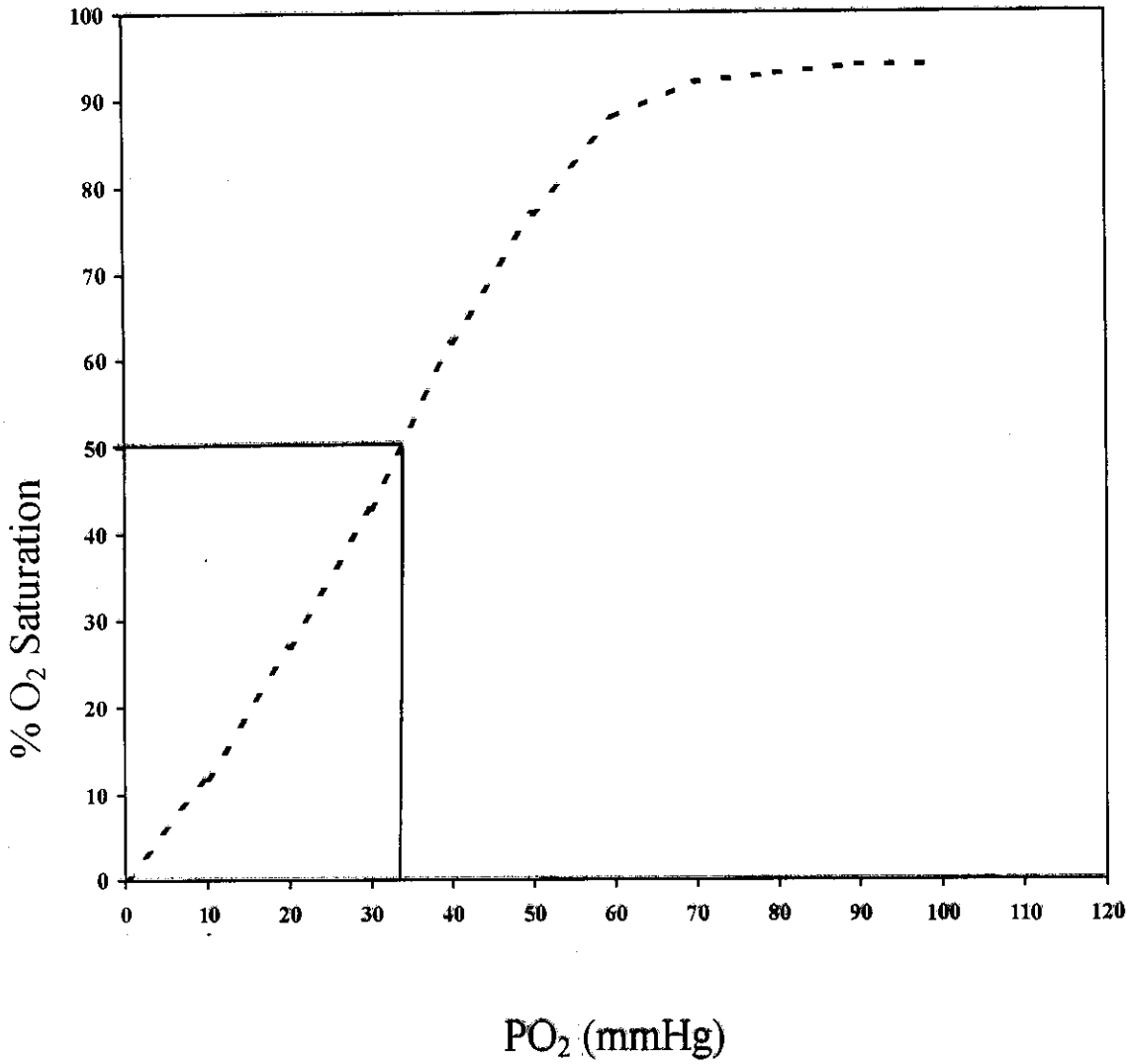


Fig. (26): Oxygen equilibrium curve of the common buzzard *(Buteo buteo vulpinus)*

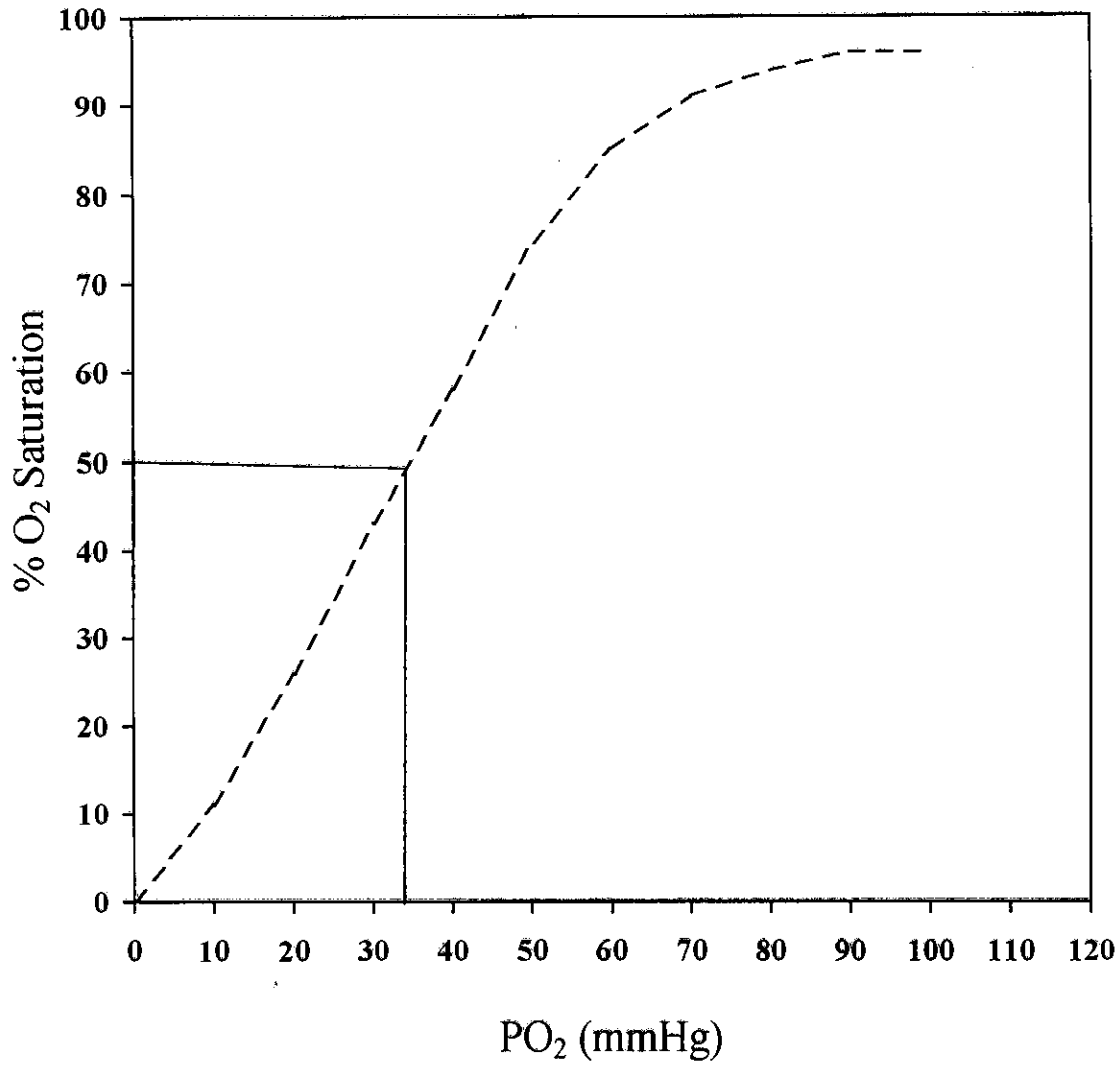


Fig. (27): Oxygen equilibrium curve of the moorhen *(Gallinula chloropus)*

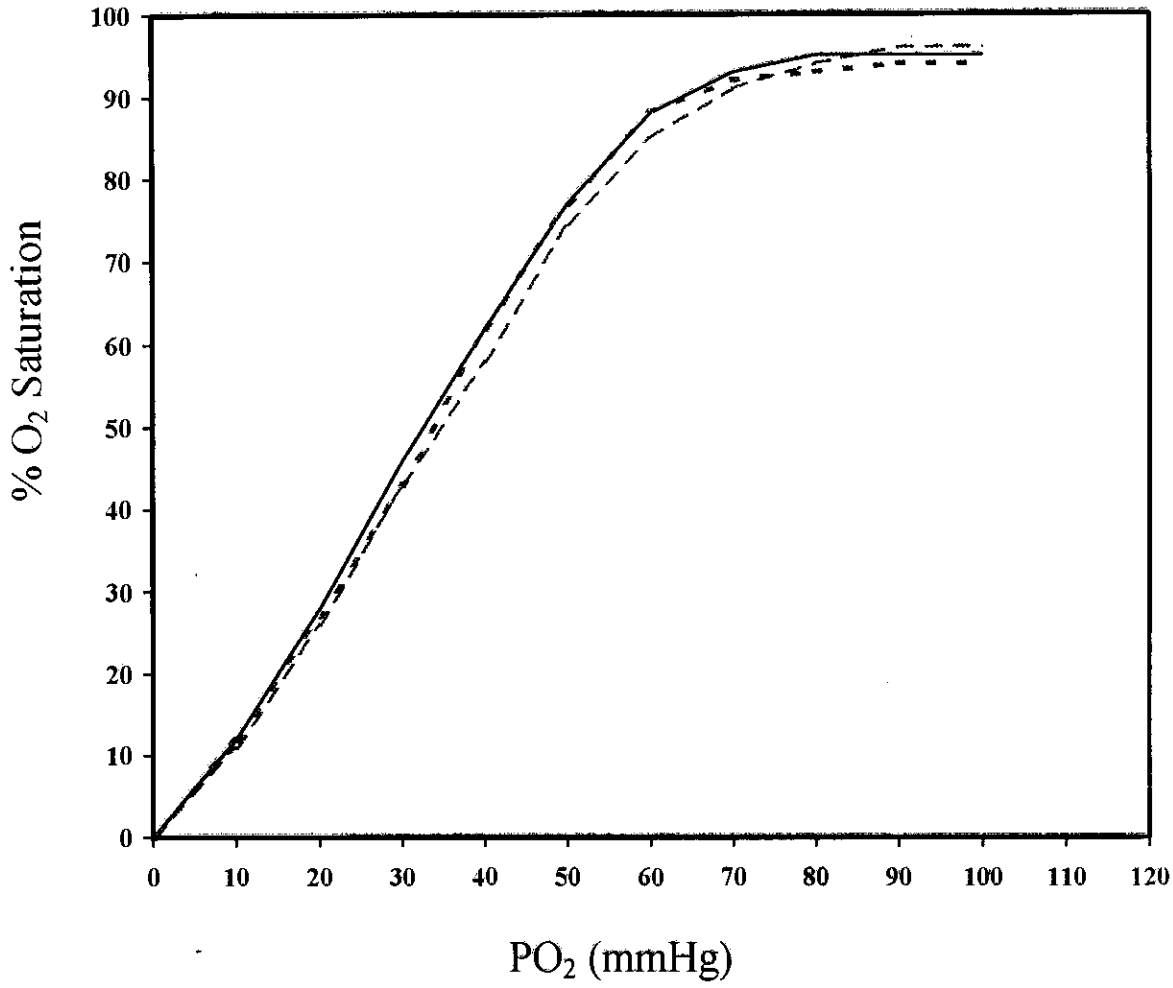


Fig. (28): Oxygen equilibrium curves of the of pigeon *(Columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and the moorhen *(Gallinula chloropus)* .

Part III: Some metabolite, enzyme and hormone activities in the three studied birds

a-Metabolites

1-Serum Glucose Level

Serum glucose level of the flightless bird (moorhen) was found to be lower than that of flying birds (pigeon and buzzard) Statistically, the difference was found to be significant ($P<0.001$) between the buzzard and moorhen, which was illustrated in (fig. 29 & table 5).

Nonsignificant difference between serum glucose levels of the pigeon and buzzard.

2-Liver Glycogen Concentration

Liver glycogen of the flying birds were found to be lower than the corresponding one of the flightless bird (Table 5). Statistical comparison of the data revealed a significant difference ($P<0.001$) between the moorhen and pigeon. Also the moorhen and buzzard showed a significant difference ($P<0.001$). Similarly significant difference ($p<0.001$) between the pigeon and buzzard. This was illustrated in fig (30).

Table (6) : Some metabolite levels (in serum or tissue) of pigeon *(Columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and the moorhen *(Gallinula chloropus)*

Metabolites	Pigeon			Buzzard			Moorhen		
	M ± SD	Range		M ±SD	Range		M ±SD	Range	
Glucose (mg /dl)	339.00 ± 34.300	302.00 - 395.00	$^{++}\alpha$	355.70 ± 18.80	328.000 - 386.00	$^{++}\beta$	319.00 ± 9.40	303.00 - 335.00	^{+++}c
Liver glycogen (mg/g tissue)	0.17 ± 0.009	0.16 - 0.19	$^{+++}\alpha$	0.11 ± 0.01	0.074 - 0.14	$^{+++}\beta$	0.26 ± 0.02	0.22 - 0.29	^{+++}c
Muscle glycogen (mg/g tissue)	0.21 ± 0.040	0.16 - 0.25	α	0.10 ± 0.01	0.097 - 0.13	$^{++}\beta$	0.25 ± 0.02	0.22 - 0.28	^{++}c
Total protein (g/dl)	1.70 ± 0.200	1.20 - 2.00	$^{++}\alpha$	2.60 ± 0.10	2.100 - 2.90	$^{++}\beta$	2.50 ± 0.30	2.00 - 2.90	c
Total lipids (mg/dl)	781.80 ± 60.000	661.60 - 945.00	$^{+++}\alpha$	549.20 ± 37.60	504.400 - 594.20	$^{+}\beta$	664.50 ± 42.10	606.80 -728.80	^{+++}c
Triglycerids (mg/dl)	332.30 ± 68.200	210.90 - 418.80	$^{+++}\alpha$	98.50 ± 4.20	93.400 - 106.00	$^{+}\beta$	119.00 ± 13.30	70.50 -194.67	^{+++}c
Cholesterol (mg/dl)	258.07 ± 28.400	226.30 - 2 98.90	$^{++}\alpha$	213.30 ± 12.50	200.100 - 244.40	$^{++}\beta$	210.00 ± 8.10	200.10 -234.20	c
Uric acid (mg/dl)	6.80 ± 0.700	3.10 - 7.90	$^{+++}\alpha$	8.70 ± 0.60	8.200 - 9.60	$^{++}\beta$	11.40 ± 1.40	9.40 - 13.80	^{++}c

M = Mean 7 measurements

SD = standard deviation

α = Relation between pigeon and common buzzard

β = Relation between pigeon and moorhen

c =Relation between common buzzard and moorhen

\+ = Significant difference at $P < 0.05$ (for t test)

++ = Significant difference at $P < 0.01$ (for t test)

+++= Significant difference at $P < 0.001$ (for t test)

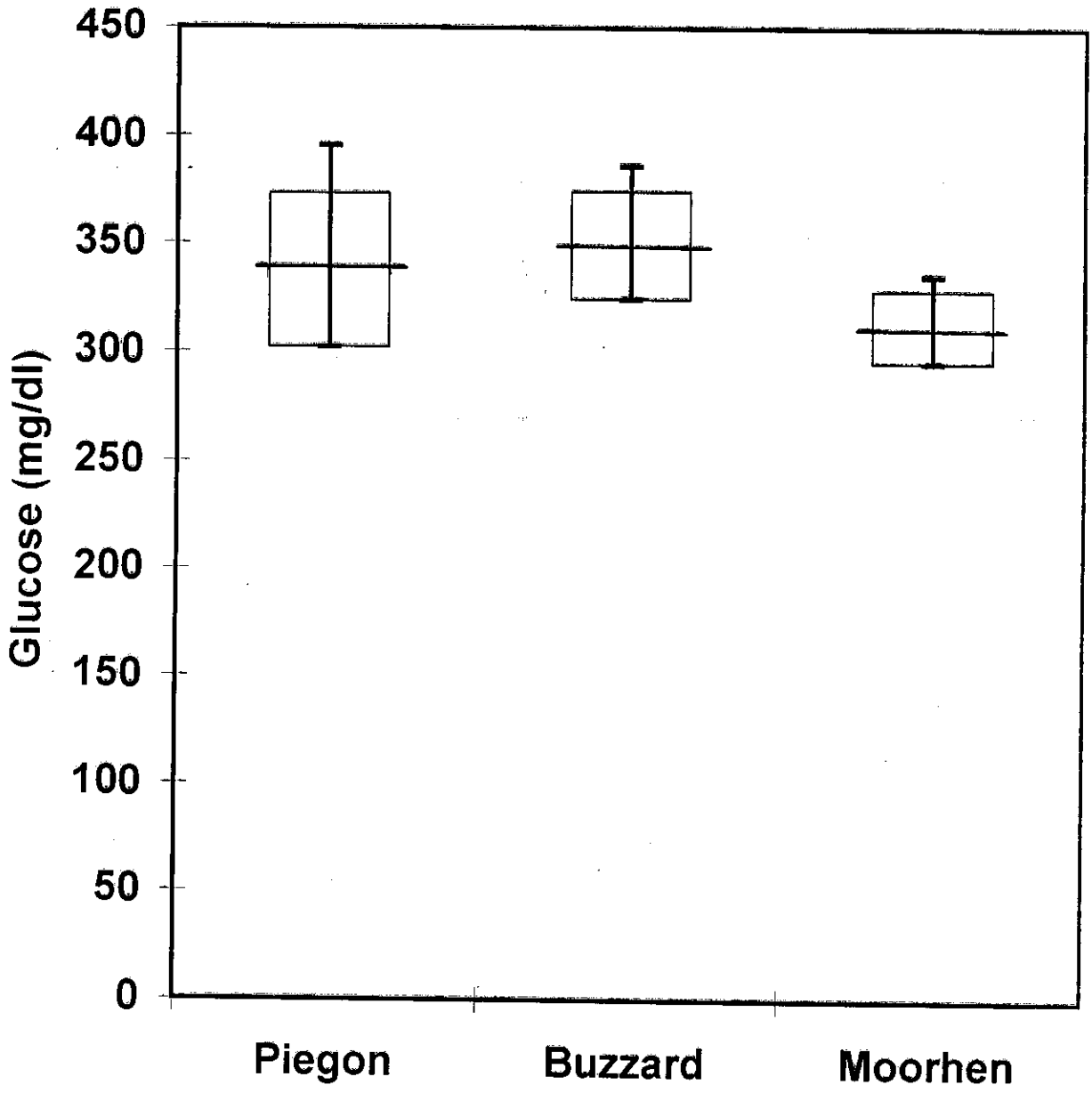


Fig (29): Serum glucose level in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

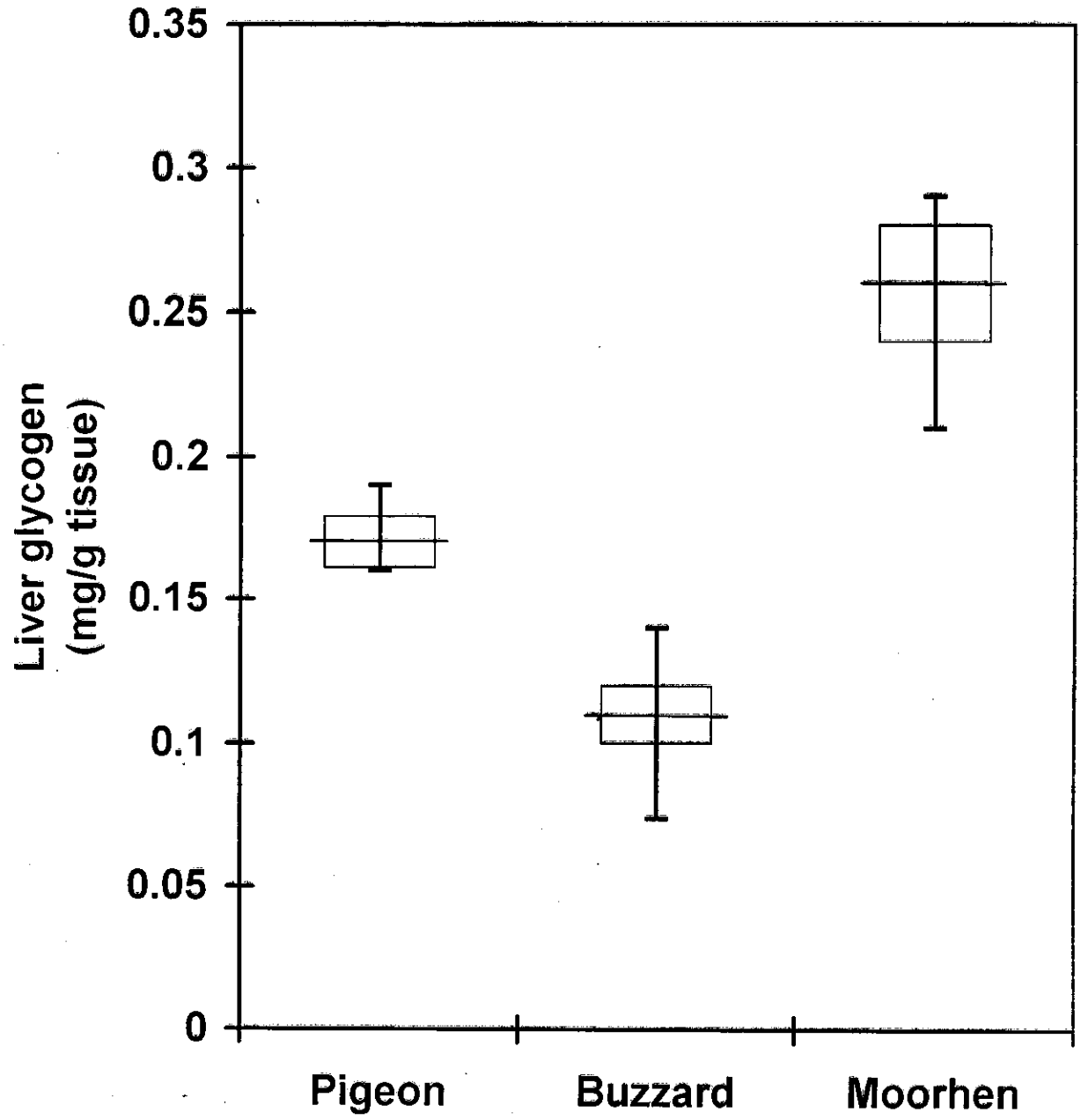


Fig (30): Liver glycogen concentration in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

3-Muscle Glycogen Concentration

Muscle glycogen concentration of the moorhen was higher than the pigeon and buzzard. Statistical comparison of the data revealed that the moorhen had a significant difference ($P<0.01$) between the pigeon and buzzard. Nonsignificant difference between the pigeon and buzzard was also illustrated in table (5) & fig (31).

4-Serum Total Proteins

The. amount of serum total proteins of the buzzard was found significantly higher ($P<0.01$) than that of the pigeon and moorhen. There was a significant difference ($P<0.001$) between the pigeon and buzzard, and between the pigeon and moorhen. Nonsignificant difference between the buzzard and moorhen was also illustrated in fig (32) & table (5).

5-Serum Total Lipids

The statistical test analysis indicated a significant difference ($P<0.001$) between serum total lipids of the pigeon and buzzard and between those of the buzzard and moorhen. There was a significant difference ($P<0.05$) between those of the pigeon and moorhen. This was illustrated in fig. (33) & table (5) the amount of serum total lipids of the pigeon was significantly higher ($P<0.001$) than that of the buzzard and moorhen.

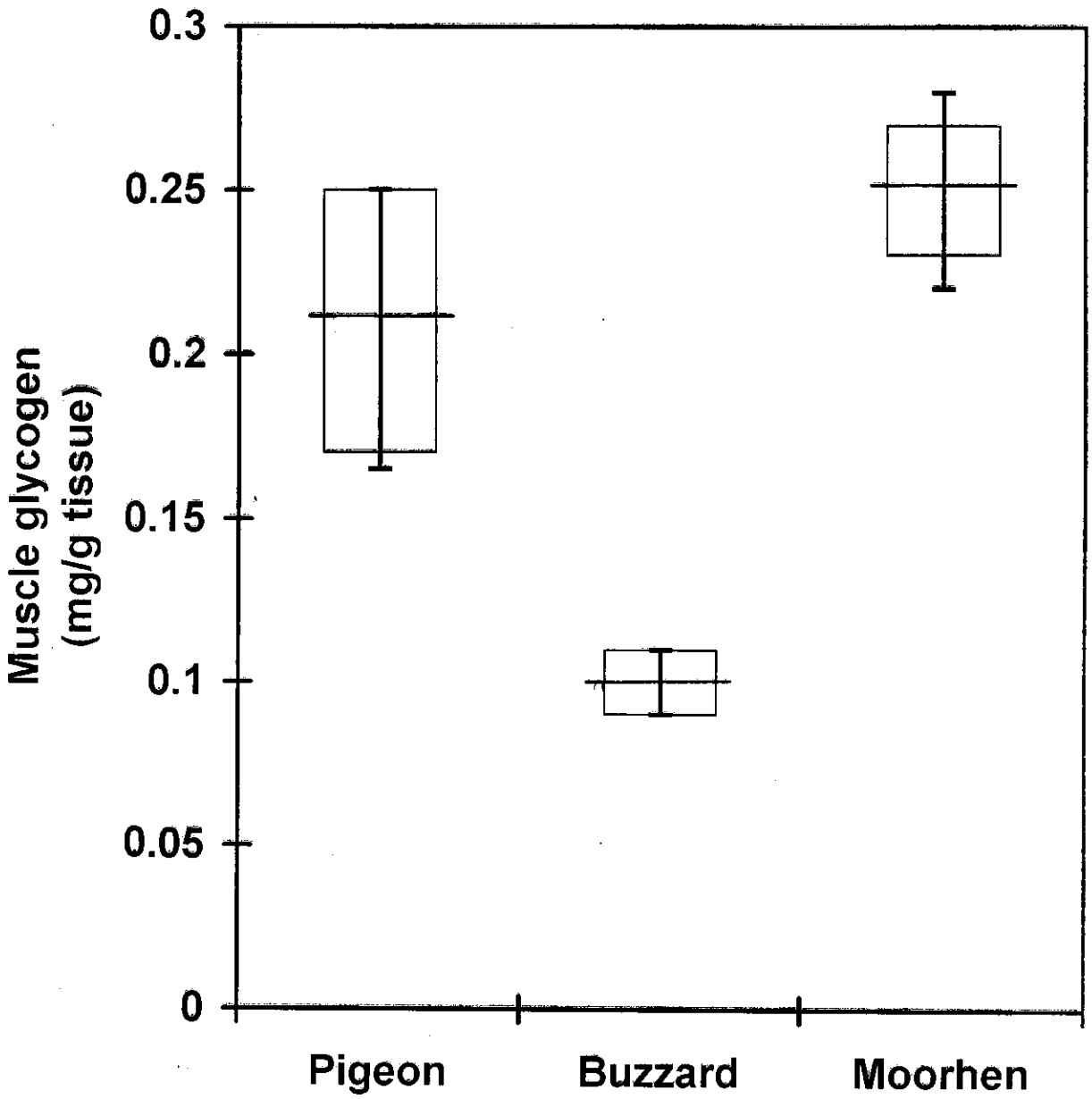


Fig (31): Muscle glycogen concentration in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

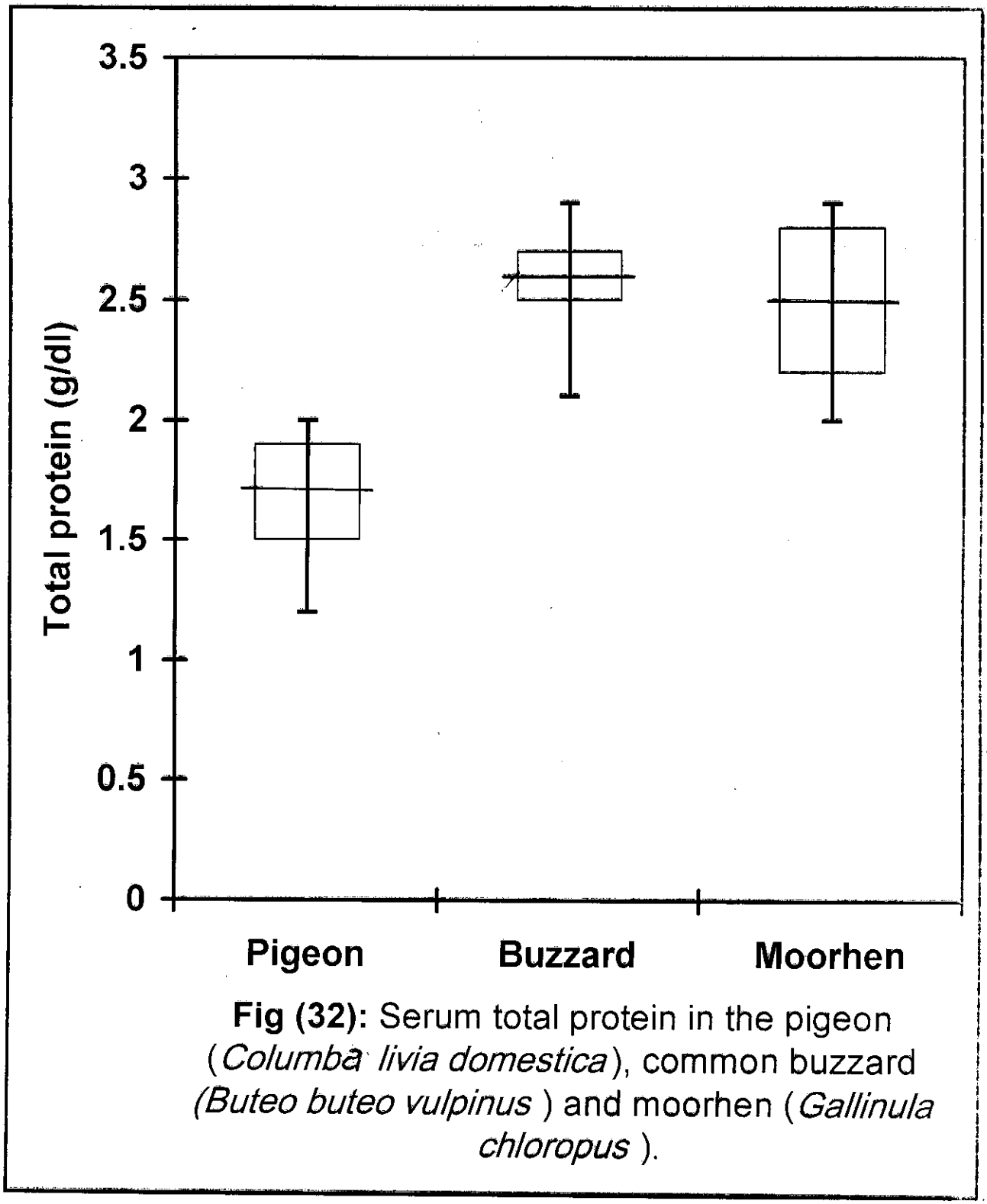


Fig (32): Serum total protein in the pigeon (*Columba livia domestica*), common buzzard *(Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

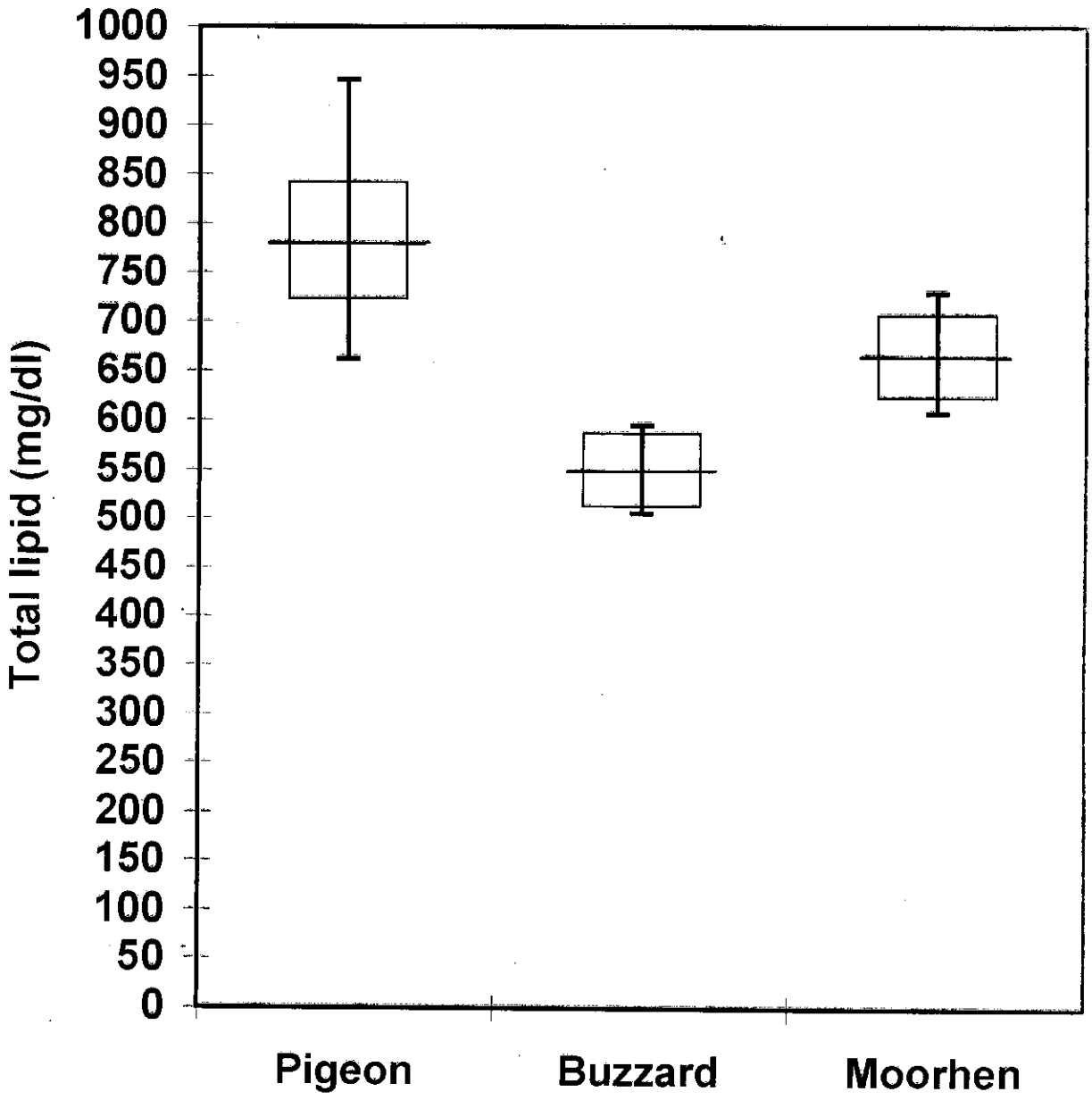


Fig (33): Serum total lipid level in the pigeon (*Columbâ livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

6-Serum Triglyceride Concentration

The serum triglyceride level of the pigeon was higher than those of the buzzard and moorhen. Statistically, there was a significant difference ($P<0.001$) between the pigeon and buzzard. Similarly there was a significant difference ($P<0.001$) between the buzzard and moorhen. The moorhen has the higher value than that of the buzzard. There was a significant difference between the pigeon and moorhen ($P<0.05$). This was illustrated in fig. (34)& table (5).

7-Serum Cholesterol Level

The serum cholesterol level of the pigeon was found to be higher than that of the buzzard. The serum cholesterol level of the pigeon showed significant differences ($P<0.01$) compared to those of the buzzard and moorhen. There was a non-significant difference between the serum cholesterol level of the buzzard and that of moorhen. This was illustrated in fig. (35) & table (5).

8-Serum Uric Acid Level

The serum uric acid level of the moorhen (flightless bird) was higher than that of the pigeon and buzzard. The moorhen showed significant difference ($P<0.01$) compared to those of the buzzard and pigeon. Also there was a significant difference ($P<0.001$) between the pigeon and buzzard. This was illustrated in fig. (36) & table (5) .

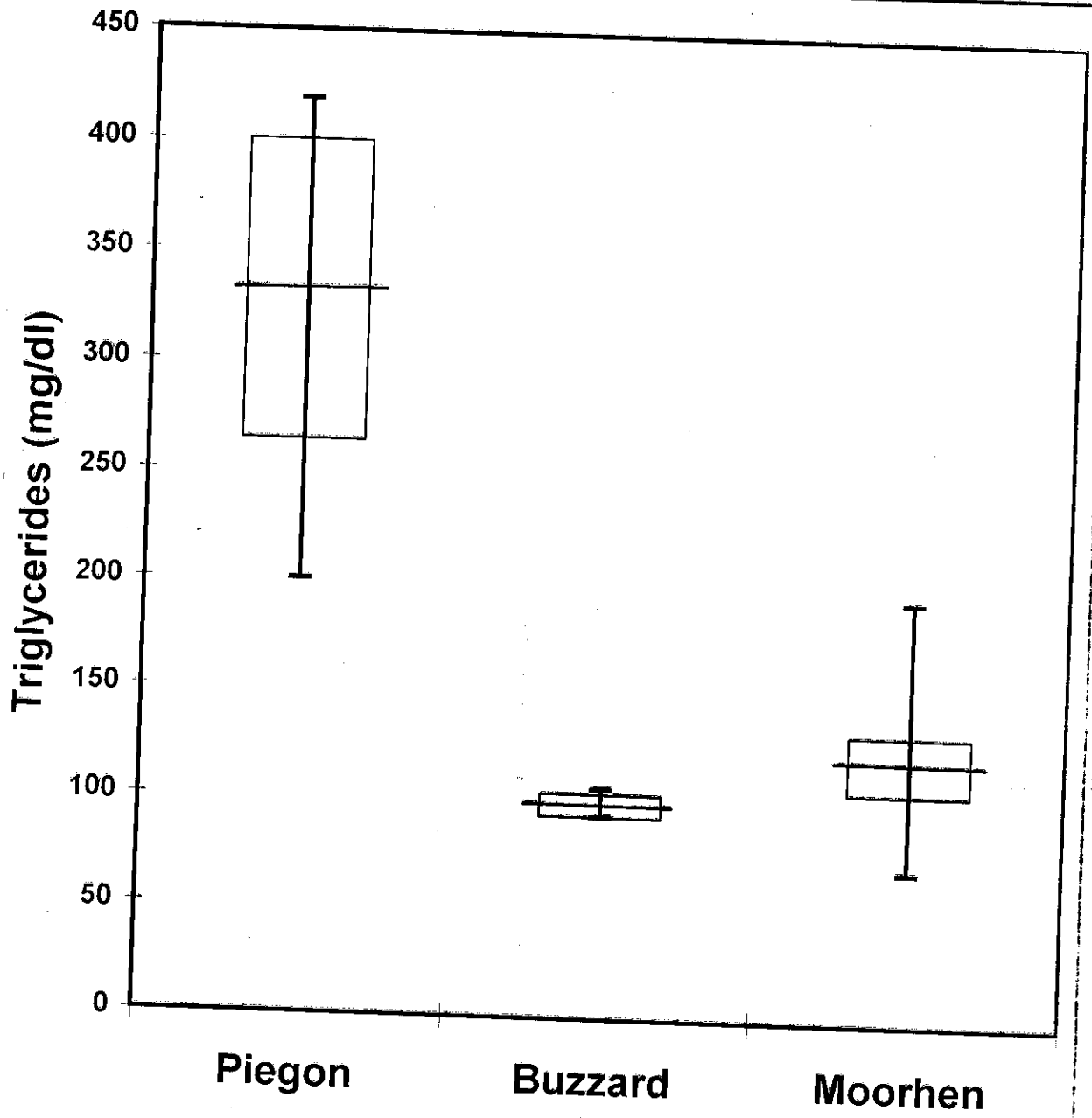


Fig (34): Serum triglyceride corncentrationin in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

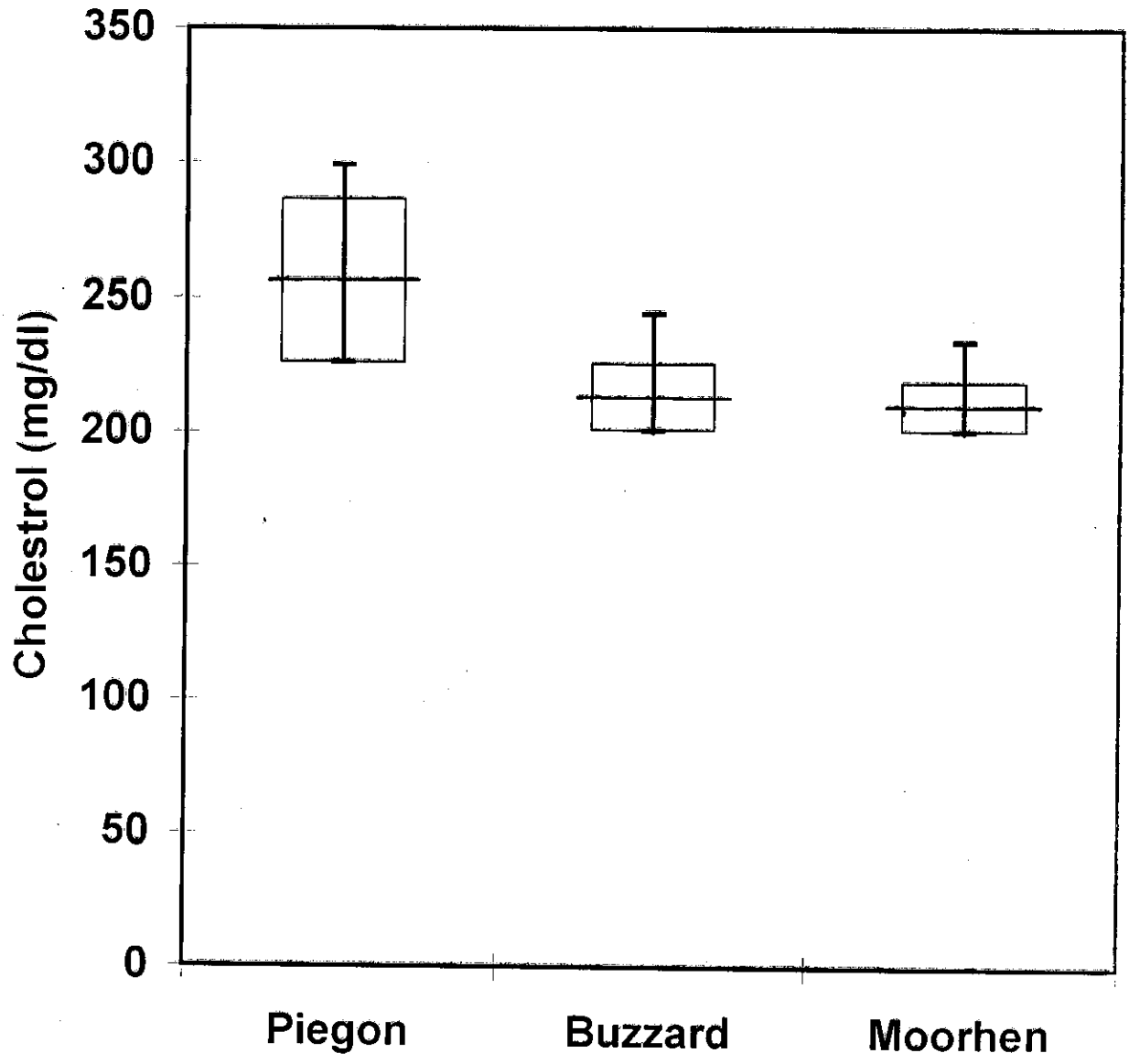


Fig (35): Serum cholestrol level in the pigeon (*Columbā livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

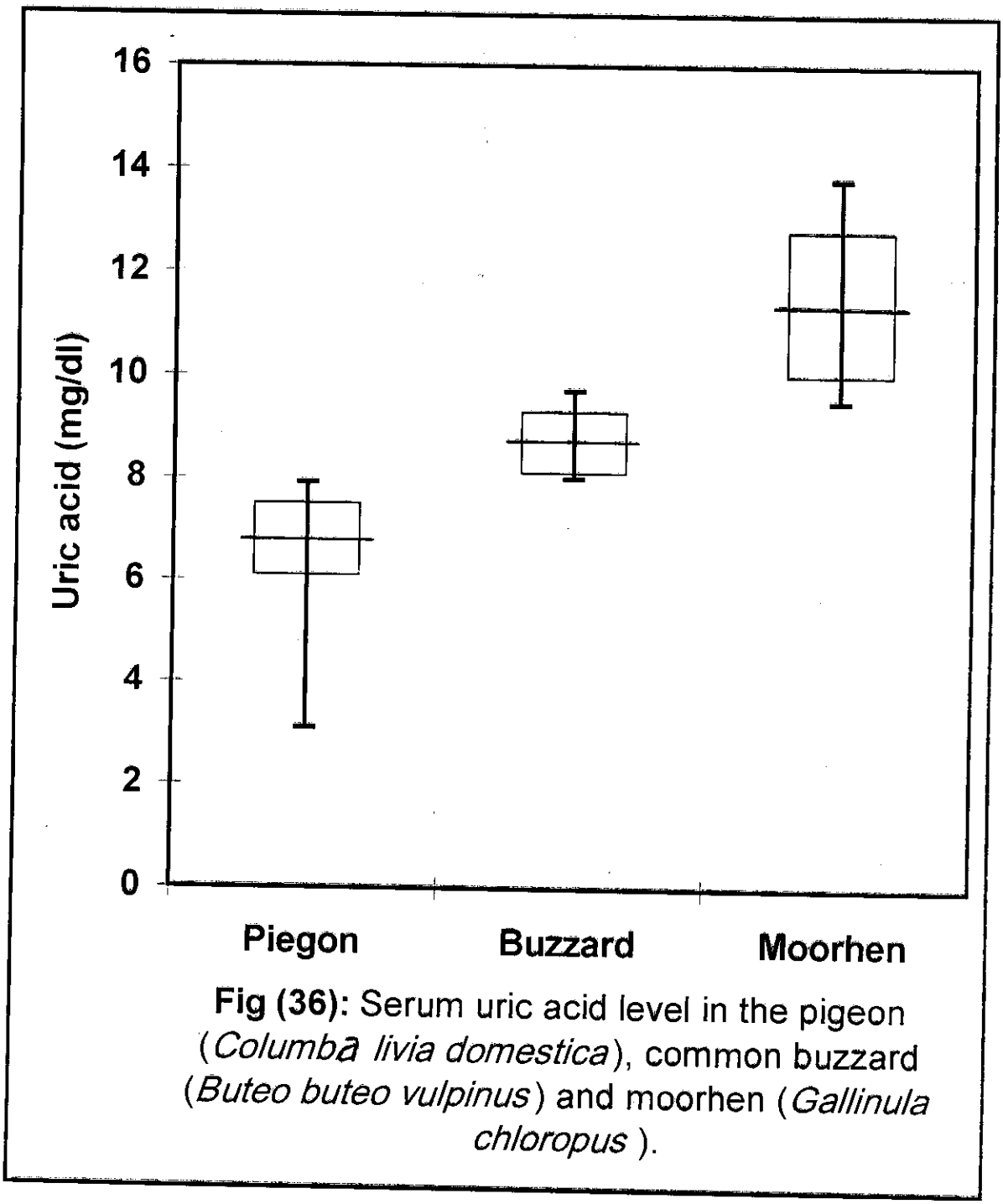


Fig (36): Serum uric acid level in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

b-Enzymes

1-Serum Aspartate Amino Transferase (AST)

Table (6) showed that the percentage of serum AST of the buzzard was higher than that the pigeon and moorhen fig. (37) illustrated that the buzzard has a significantly higher percentage of AST ($P<0.01$) than those of the pigeon and moorhen. Also, serum AST of the moorhen was significantly lower ($P<0.01$) than the pigeon.

2-Serum Alanine Amino Transferase (ALT)

Table (6) showed that serum ALT of the buzzard was significantly higher ($P<0.001$) than that of the pigeon. Similarly, serum ALT of the pigeon was significantly higher ($P<0.01$) than the moorhen. This was illustrated in fig. (38).

c-Hormones

1-Insulin level

Serum insulin level of the pigeon was higher than those of the buzzard and moorhen. This was illustrated in fig. (39) & table (7). The level of the buzzard was significantly higher ($P<0.01$) than moorhen. On the other hand the level of the pigeon was significantly higher than that of the moorhen ($P<0.001$).

Table (7) : Activities of aspartate amino transferase (AST) and alanine amino transferase (ALT) in the serum of pigeon *(Columba livia domestica)*, common buzzard *(Buteo buteo* vulpinus*)* and the moorhen *(Gallinula chloropus)*

Enzymes	Pigeon			Buzzard			Moorhen		
	M ± SD	Range		M ±SD	Range		M ±SD	Range	
AST (u/l)	63.5 ± 13.90	47 - 76	$^{++}\alpha$	68.7 ± 15.0	52 - 89	$^{++}\beta$	36.50 ± 7.5	27.0 - 47	^{++}c
ALT (u/l)	17.1 ± 2.30	14 - 28	$^{+++}\alpha$	31.8 ± 7.5	24 - 48	$^{++}\beta$	8.20 ± 1.3	7.0 - 10	^{++}c

M = Mean 7 measurements

SD = standard deviation

α = Relation between pigeon and common buzzard

β = Relation between pigeon and moorhen

c =Relation between common buzzard and moorhen

\+ = Significant difference at $P < 0.05$ (for t test)

++ = Significant difference at $P < 0.01$ (for t test)

+++= Significant difference at $P < 0.001$ (for t test)

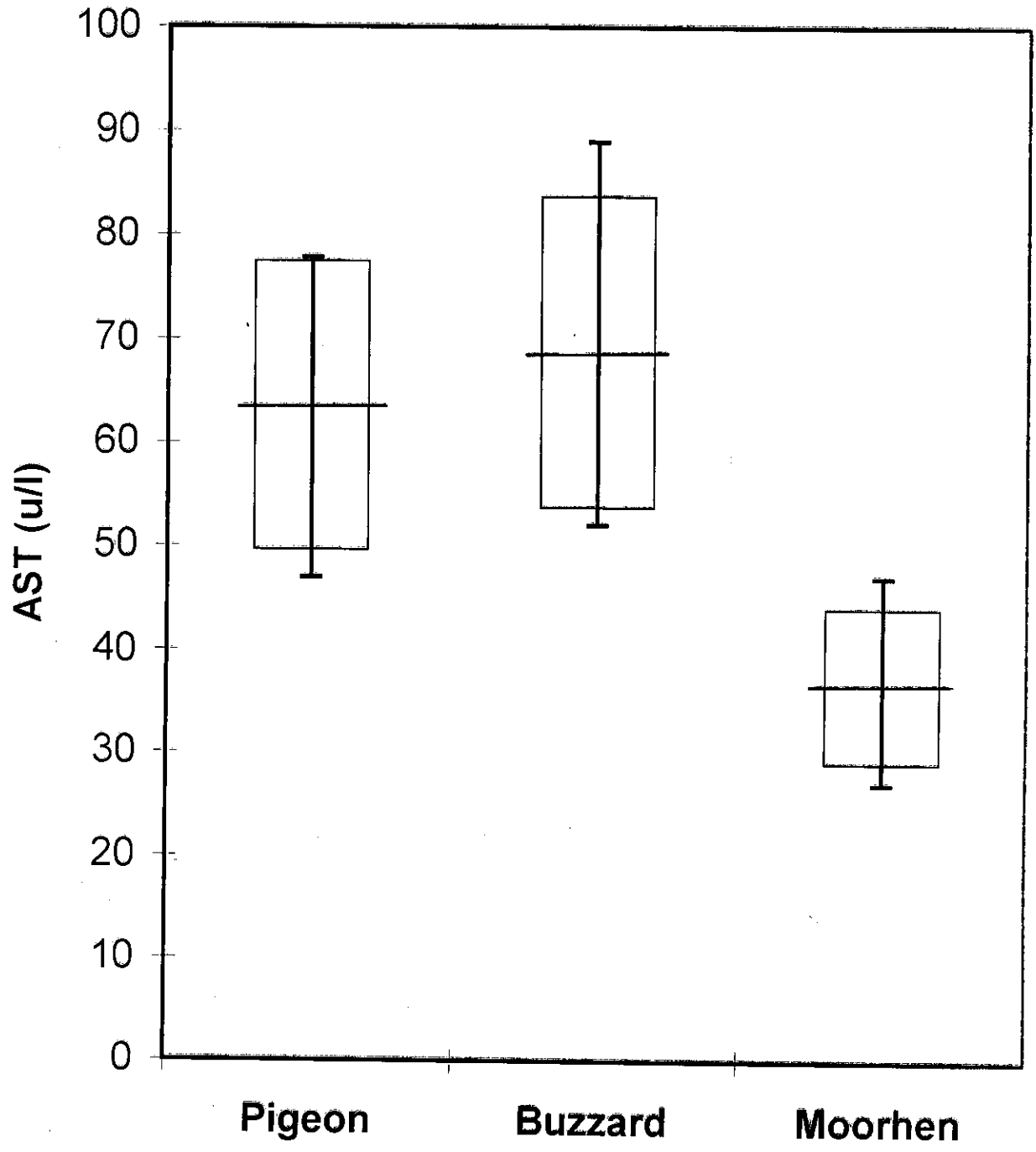


Fig (37): Serum aspartate aminotranferase (AST) in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

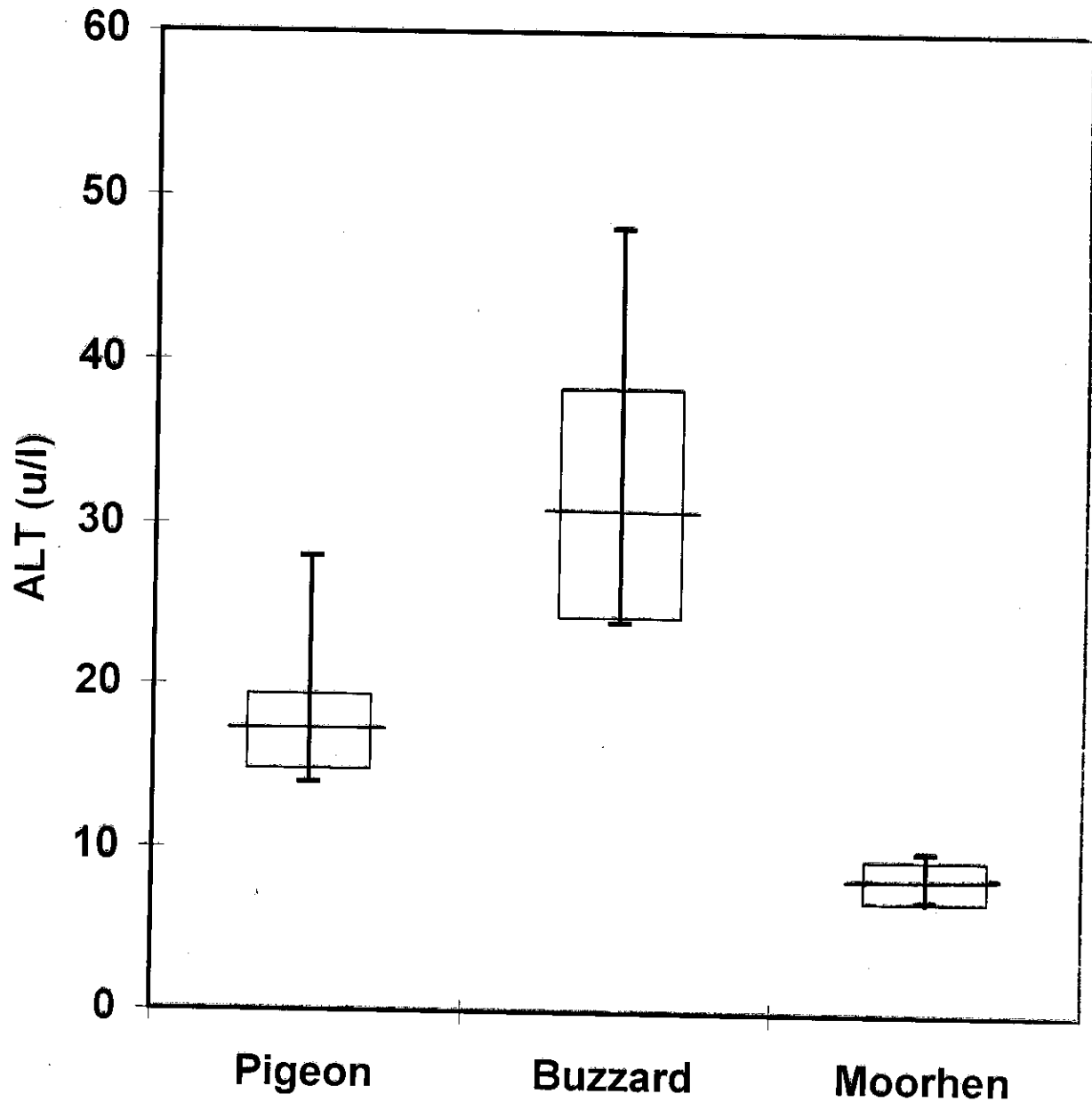


Fig (38): Serum alanine aminotransferase (ALT) in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

Table (٤) : Some hormone Levels in the serum of pigeon *(Columba livia domestica)*, common buzzard *(Buteo buteo vulpinus)* and the moorhen *(Gallinula chloropus)*

Hormones	Pigeon			Buzzard			Moorhen		
	M ± SD	Range		M ±SD	Range		M ±SD	Range	
Insulin (μ/ml)	1.05 ± 0.40	0.2 - 1.50	$^{+++}\alpha$	0.57 ± 0.040	0.10 - 1.00	$^{+++}\beta$	0.40 ± 0.10	0.10 - 0.60	^{---}c
T3 (ng/dl)	204.90 ± 59.80	137.9 - 288.50	$^{+}\alpha$	64.80 ± 15.900	49.20 - 76.20	$^{+}\beta$	80.30 ± 10.30	63.30 - 91.02	^{-}c
T4 (μg/dl)	0.90 ± 0.40	0.1 - 1.80	α	0.67 ± 0.200	0.40 - 0.90	β	0.88 ± 0.05	0.80 - 0.97	^{--}c
Cortisol (μg/dl)	0.12 ± 0.01	0.1 - 0.15	$^{+}\alpha$	0.07 ± 0.007	0.03 - 0.08	$^{+++}\beta$	0.05 ± 0.02	0.03 - 0.09	c

M = Mean 7 measurements

SD = standard deviation
α = Relation between pigeon and common buzzard
β = Relation between pigeon and moorhen
c =Relation between common buzzard and moorhen
+ = Significant difference at $P < 0.05$ (for t test)
++ = Significant difference at $P < 0.01$ (for t test)
+++= Significant difference at $P < 0.001$ (for t test)

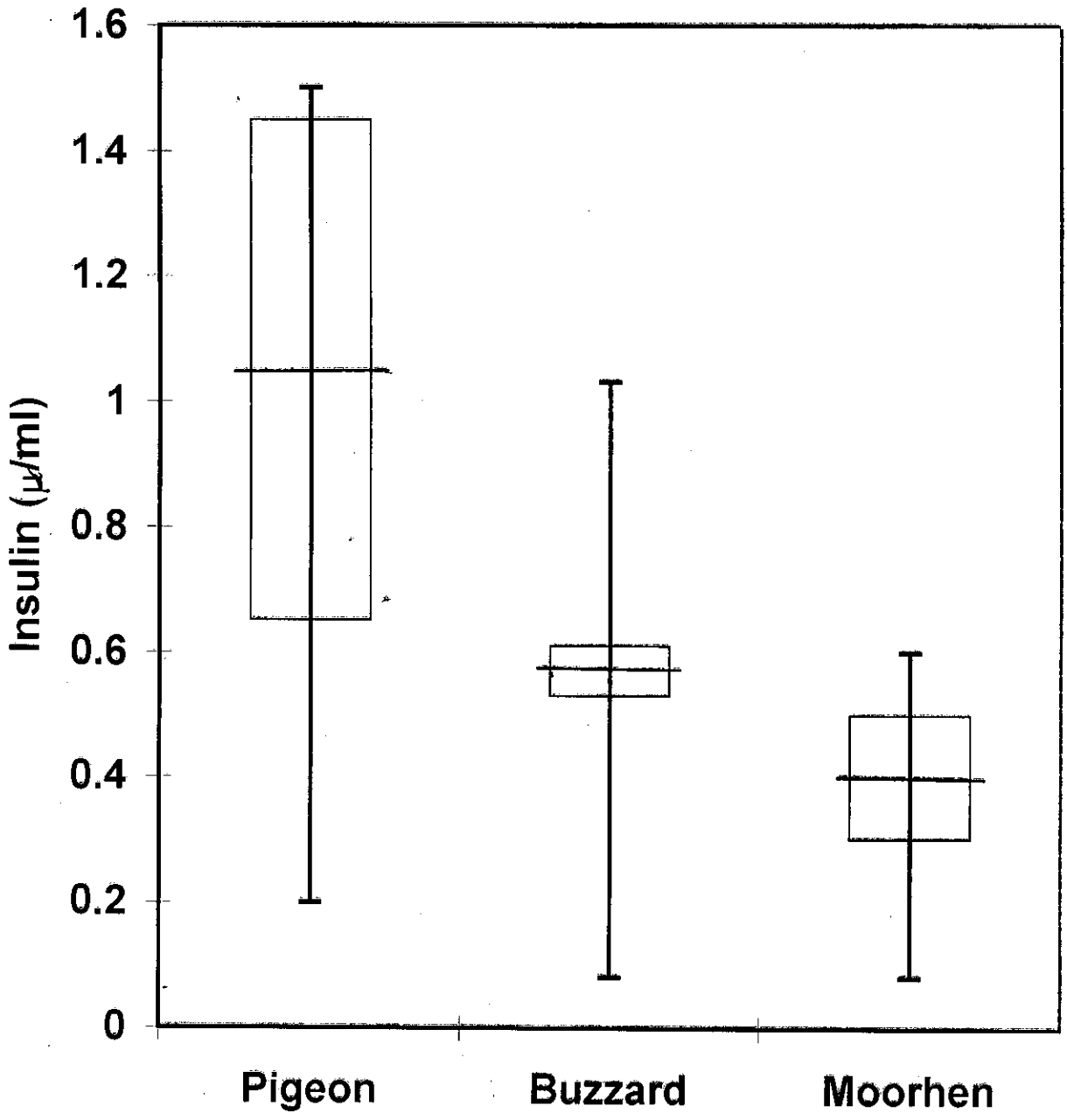


Fig (39): Insulin level in the pigeon (*Columbà livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

2-Triiodothyronine T_3

The serum level of T_3 hormone of the pigeon was higher level than that of the buzzard and moorhen. The pigeon showed significantly higher than those of the buzzard and moorhen ($P < 0.05$). Also, the level of the moorhen was significantly higher than that of the buzzard ($p<0.05$) fig. (40) & table (7).

3-Tetraiodothyronine (T_4)

The serum level of T_4 hormone of the pigeon was higher than that of the buzzard and moorhen fig. (41) & table (7). The pigeon showed nonsignificant difference in serum level of T_4 as compared to that of the buzzard and moorhen. On the other hand the moorhen was significantly higher ($P<0.01$) than the buzzard.

4-Cortisol Level

The serum cortisol level of the pigeon was higher than those of the buzzard and moorhen. The pigeon showed significantly higher levels than those of the moorhen and buzzard ($p<0.001$) and ($P<0.05$) respectively. There was a nonsignificant difference between the level of the buzzard and moorhen fig. (42) & table (7).

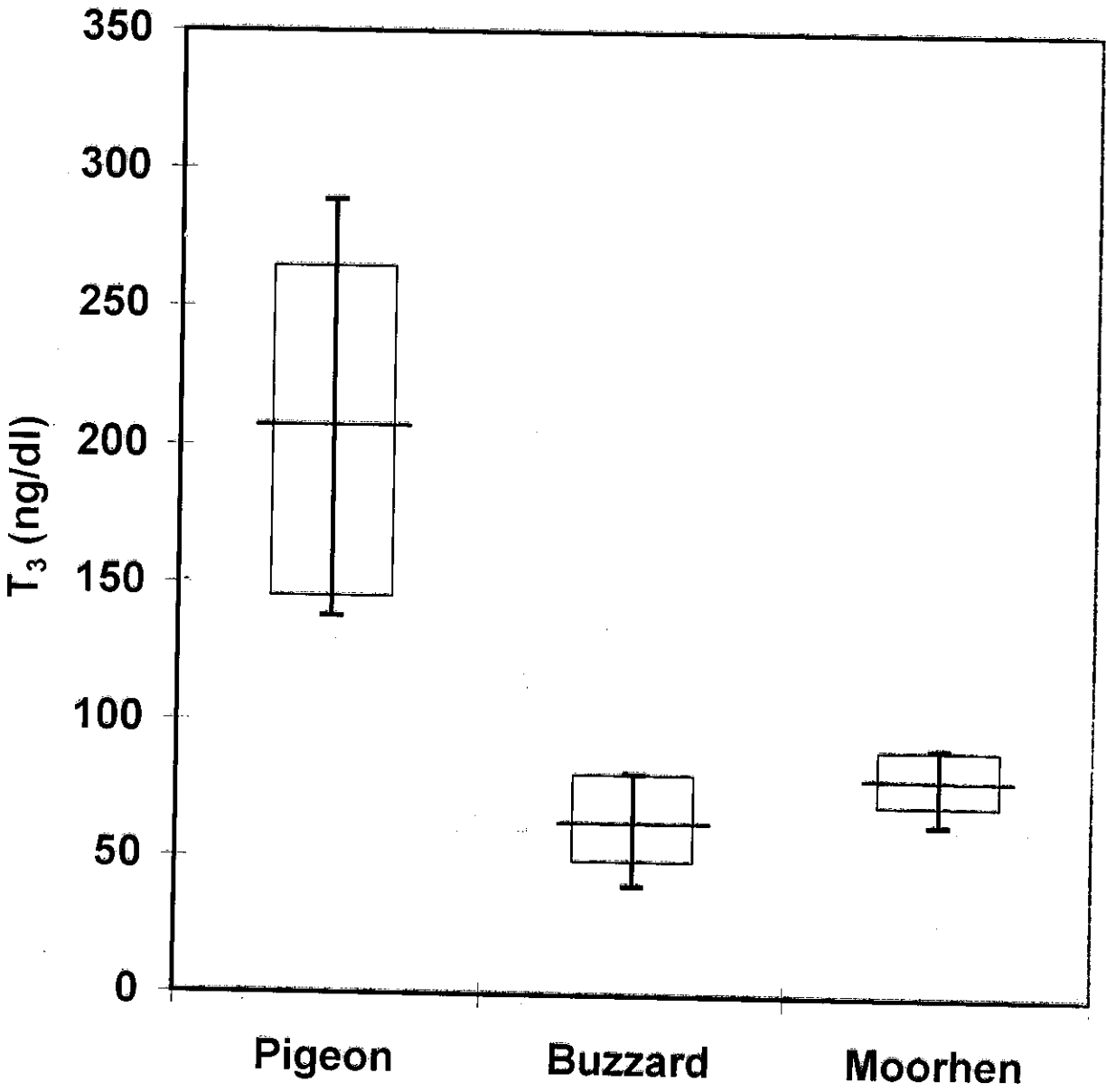


Fig (40): Serum triiodothyronine level in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

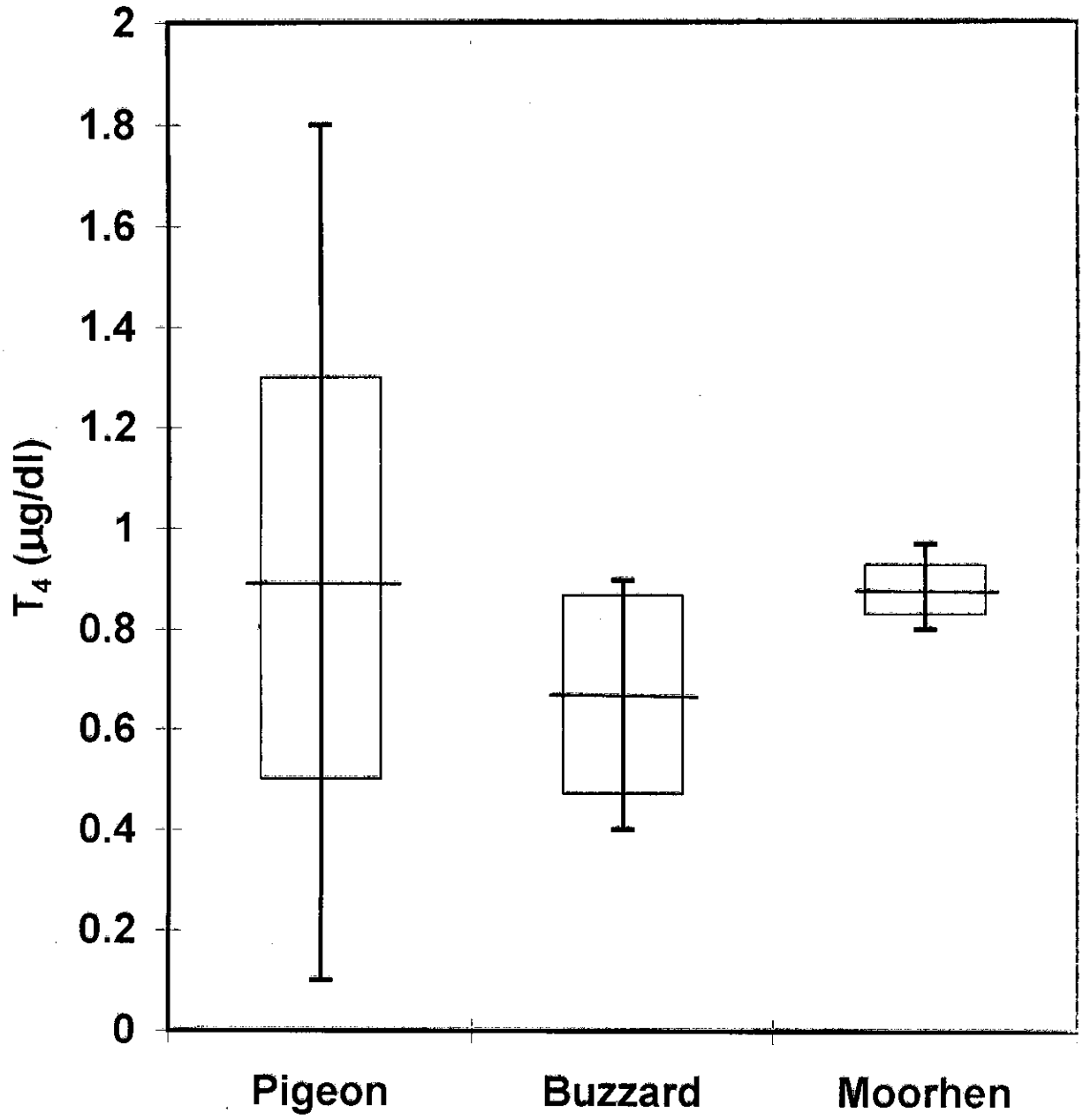


Fig (41): Serum tetraiodothyronine level in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).

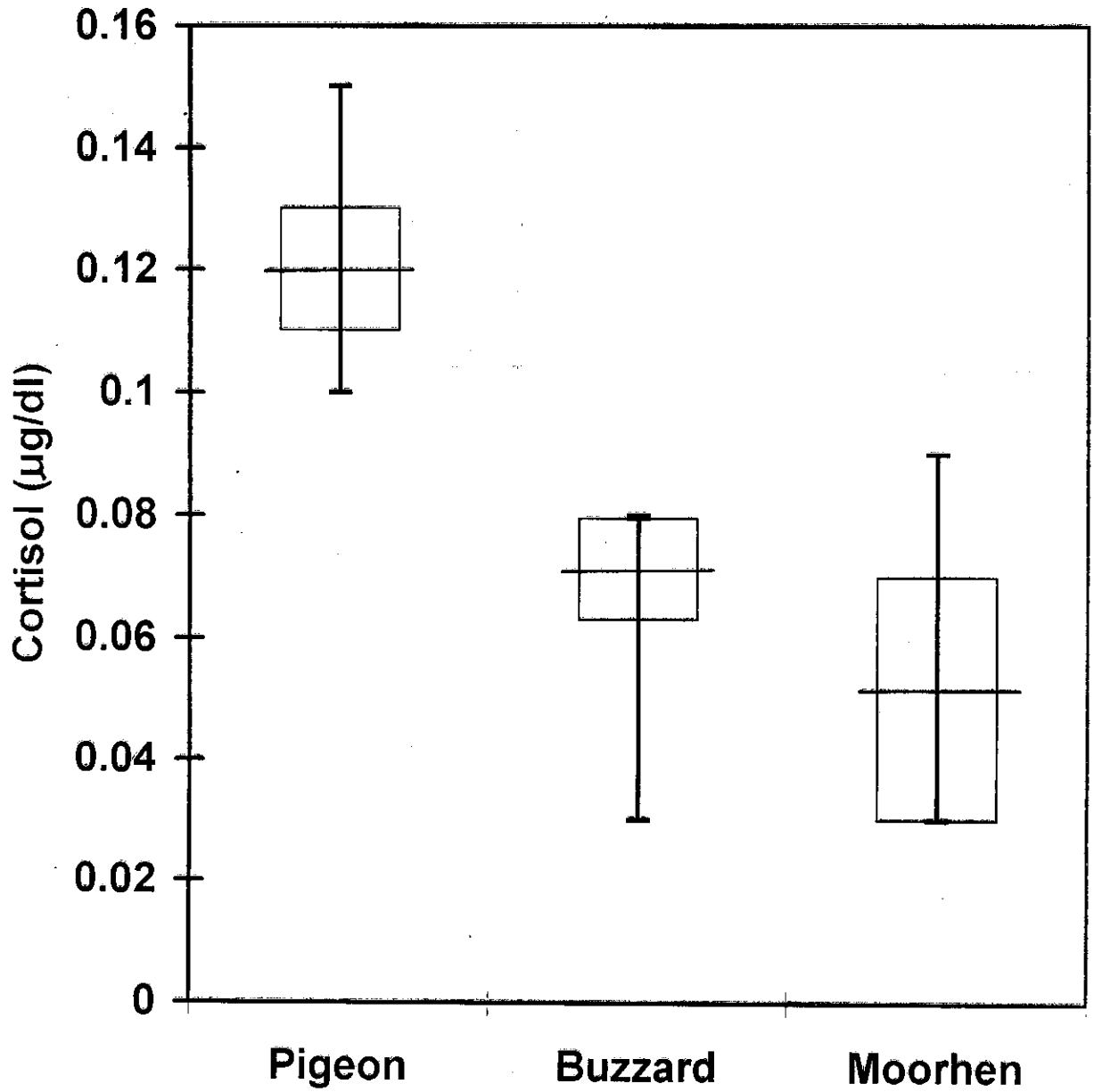


Fig (42): Serum cortisol level in the pigeon (*Columba livia domestica*), common buzzard (*Buteo buteo vulpinus*) and moorhen (*Gallinula chloropus*).