www.roavs.com EISSN: 2223-0343
RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Effect of rearing system, slaughter age and sex on turkey (*Meleagris gallopavo*) carcass components percentages

R. M. Shamseldin[1], S. Gibril[2], M. Atta[2*], O. E. Yassin[1] and A. A. Hassan[3]

[1]College of Animal Production, Sudan University of Science and Technology, Sudan;
[2]College of Animal Production, University of Bahri, Khartoum, Sudan;
[3]College of Agricultural Technologies and Fish Sciences, University of Al-Neelain, Sudan

Abstract

The objective of this study was to examine the burden of rearing system, slaughter age and sex on slaughter body weight, carcass weight and various carcass cuts percentages of turkeys (*Meleagris gallopavo*). 25 male and 24 female turkey growers were reared under semi intensive (13 males and 12 females) or extensive systems (12 males and 12 females). Eight males and 7 females of the semi intensive group were slaughtered at the 16th week of age and the rest of birds in the group (5 males and 5 females) were slaughtered at the 28th week of age. Regarding the extensive system group, 7 males and 7 females were slaughtered at the 16th week of age, whereas 5 males and 5 females were slaughtered at the 28th week of age. The results showed that birds slaughter at the 28th week had higher slaughter weight, carcass weight, dressing percentage and percentage of breast cut weight and had lower percentages of wing tip, middle wing, drum matte, drum stick cuts weights than their fellow mates slaughtered at the 16th week of age. Males always excelled females in slaughter weight, carcass weight and percentages of neck and thigh cuts weights. Only the breast cut weight increased at significantly faster rate than the whole carcass weight. It was increasing by 1.246% for each 1% increase of the carcass weight. Neck and thigh cuts weight increased at the same rate of the whole carcass weight (increase rates of 0.995 and 0.983%). The other cuts weights had significantly lower relative increase coefficients (ranging between 0.238 and 0.863%). It can be concluded that the slaughter age and sex significantly altered the percentages of the carcass components. Slaughtering at 28 weeks of age produced high yield of carcass. The system of rearing showed an insignificant load on the carcass components percentages. It is evident that the development of turkey's carcass weight depended mainly on the breast cut weight increase.

Keywords: Carcass; carcass components; Turkeys

To cite this article: Shamseldin RM, S Gibril, M Atta, OE Yassin and AA Hassan, 2014. Effect of rearing system, slaughter age and sex on turkey (*Meleagris gallopavo*) carcass components percentages. Res. Opin. Anim. Vet. Sci., 4(4): 198-202.

Introduction

Modern turkey breeds have high yield of meat that reach as high as 23.9 kg and 12.85 kg at 24 weeks of age for male and female, respectively, under ideal management conditions (British United Turkeys, 2005). Isguzar (2003) reported 15844 and 11797 grams, live weight at 18 weeks from male and female white turkey, respectively. In addition, the same author reported that turkey carcasses have high dressing percentage (74-82%). Most of variations in the wholesale cuts percentages are expected to associate with differences in total lean and fat yield that is mainly dependent on slaughter weight. An understanding of development of turkey's body weight is very important to improve meat production and produce more desirable meat products. Mathematical modelling has been widely used to describe biological phenomena as growth of animal body and its components. The function $y = ax^b$ or its logarithmic form ($\log y = \log a + b*\log x$) was used to describe the percentage of the increase of a component weight (y) at 1% increase of the whole slaughter or carcass weight (x) (Wanger et al., 1999).

Corresponding author: M. Atta, Department of Animal resources, Ministry of Environment, The State of Qatar. P.O. Box 23211

In the Sudan, turkeys' rearing was initiated using commercial breeds with promising results in the semi-intensive and extensive systems (Gibril et al., 2013 a&b). Roberson et al. (2004) reported that sex and slaughter age influenced carcass characteristics of turkeys. Information on the effect of rearing system, slaughter age and sex on carcass components of commercial breeds of turkeys are not available in Sudan. The availability of such information is very important to provide data base for this type of poultry. In addition, the knowledge of carcass characteristics at different ages will help in understanding the meat qualities and production potential of turkey.

The objective of this study was to examine the effects of semi intensive and extensive rearing systems, slaughter age and sex on the components of turkey's carcass. Investigation of the role of the increase of weights of the different carcass components on the development of the whole carcass weight was also aimed.

Materials and Methods

This study program on turkey (*Meleagris gallopavo*) under two systems of management was conducted at the College of Natural Resources Farm, University of Bahri, Khartoum north, from June to November 2011. Turkey growers of the British United Turkey (BUT Big 6) breed were managed under semi-intensive or extensive systems. The semi-intensive system was a deep litter open sided poultry house where turkeys were accommodated inside an experimental pens of 1×2×3 meters dimension made of strong iron expenders. While the extensive system was a fenced experimental areas each of 17.5×15 meters dimensions where birds were allowed to roam freely inside and to take shelter in an experimental pen of 4×7 meters dimensions where feed and water were provided.

A total of 49 turkey growers (25 males and 24 females) were used in this experiment. Twenty nine of them were slaughtered at week 16 of age and 20 growers were slaughtered at week 28 of age. Among the birds slaughtered at week 16 of age, 15 birds (8 males and 7 females) were reared under the semi-intensive system and 14 birds (7 males and 7 females) were reared under the extensive system. Regarding the birds slaughtered at week 28 of age 10 birds (5 males and 5 females) were chosen from each system. The carcasses of the slaughtered birds were then cut into various carcass components as described by Jensen (1983). The data of slaughter, carcass and carcass components weights were grouped and analyzed to evaluate the effect of system of management (extensive and semi-intensive), slaughter age (at week 16 and week 28) and sex of turkeys.

Statistical analysis

The data were analyzed by 3-way analysis of variance to test the effect of system of management, slaughter age and sex on the dressing percentage and carcass cuts percentages . The significance of differences between means of treatments was tested by Duncan multiple range test (StatSoft, 2010).

To test the percent of carcass cuts weight (y) increase when the carcass weight (x) increased by 1%, logarithmic regressions were performed to each carcass cuts at the pooled data level and at the levels of each tested variable (slaughter ages, systems of management and sex). The significance of differences between the levels of each variable on the regression coefficients (constant *b*) was tested according to Ali (2008).

Results and Discussion

Table 1 shows the effects of slaughter age (week 16 vs. week 28), system of management (semi intensive vs. extensive) and sex (male vs. female) on the slaughter and carcass weight, percentages of dressing and carcass components percentages cuts. The results indicated that turkeys slaughtered at week 28 of age had significantly heavier slaughter and carcass weights and higher dressing percentage than their fellow mates slaughtered at week 16. This increase of slaughter and carcass weights and dressing percentage with the advancement of age was consistent with Aviagen Turkeys (2013). Lawrence and Fowler (1997) attributed this to body muscles which are late maturing and their percentage will increase with age rather than the non-carcass components and bones. The results also showed that male turkeys had heavier slaughter and carcass weights than female ones, however, due to the significant effect of slaughter week and sex interaction, this variation was not significant among turkeys slaughtered at week 16. The superiority ($P<0.05$) of males over females for carcass and component weights at a particular age agrees with the results of Zerehdaran et al. (2004) and Khosravania et al. (2006).

As far as system of management is concerned, results indicated that slaughter body and carcass weights were insignificantly better for the semi intensive system than the extensive system. However, Gordon and Charles (2002) and Gibril et al. (2013b) observed that the semi-intensive system was significantly better than the extensive system. They attributed the improved slaughter body and carcass weights at the semi intensive systems to less mobility that availed more energy to be converted into body weight. This was in agreement with Castellini et al. (2002) who noted that the performance of broilers birds with outdoor access would be inferior to that in a more controlled environment that probably could be due to exposure of the birds to fluctuating temperatures and increased exercise in the yard. The insignificance of variation between the two systems in slaughter body and carcass weights of the current study may be due to the small size sample. The insignificant variation among system of management in the percentages of carcass components is an axiomatic since the slaughter and

Table 1: Dressing and carcass cuts percentages of male and female turkeys raised under semi-intensive and extensive systems and slaughter at 16 and 28 weeks of age

Slaughter week	16	16	16	16	28	28	28	28
System	Semi-intensive	Semi-intensive	Extensive	Extensive	Semi-intensive	Semi-intensive	Extensive	Extensive
Sex	M	F	M	F	M	F	M	F
N	8	7	7	7	5	5	5	5
Slaughter weight, kg	7.3±0.33^{c}	6.5±0.35^{c}	6.6±0.35^{c}	6.1±0.35^{c}	14.4±0.41^{a}	10.1±0.41^{b}	13.5±0.41^{a}	9.9±0.41^{b}
Carcass weight, kg	5.6±0.29^{c}	5.0±0.31^{c}	5.1±0.31^{c}	4.93±0.305^{c}	12.2±0.36^{a}	8.5±0.36^{b}	11.9±0.36^{a}	8.8±0.36^{b}
Dressing, %	76.8±1.38^{c}	77.23±1.475^{c}	77.3±1.48^{c}	80.3±1.48^{bc}	85.3±1.75^{ab}	84.2±1.75^{a}	88.3±1.75^{a}	89.1±1.75^{a}
Neck, %	5.7±0.18^{bc}	5.0±0.20^{de}	5.9±0.20^{b}	5.25±0.196^{bcd}	5.3±0.23^{bcd}	5.2±0.23^{cd}	6.5±0.23^{a}	4.4±0.23^{e}
Back, %	20.1±0.54^{a}	19.7±0.57^{a}	18.6±0.57^{ab}	20.1±0.57^{a}	17.3±0.68^{bc}	16.0±0.68^{cd}	14.5±0.68^{d}	15.3±0.68^{d}
Wing tip, %	2.3±0.08^{a}	2.0±0.09^{b}	2.1±0.09^{ab}	2.0±0.09^{b}	1.0±0.11^{c}	1.2±0.11^{c}	1.2±0.11^{c}	1.2±0.11^{c}
Middle wing, %	6.4±0.16^{a}	5.3±0.17^{c}	6.0±0.17^{ab}	5.5±0.17^{bc}	3.7±0.20^{e}	4.4±0.20^{d}	4.0±0.20^{de}	4.1±0.20^{de}
Drum matte, %	7.3±0.23^{a}	7.0±0.24^{ab}	6.6±0.24^{abc}	7.2±0.24^{a}	5.5±0.29^{d}	6.3±0.29^{bcd}	6.0±0.29^{cd}	6.1±0.29^{cd}
Thigh, %	14.7±0.32^{abc}	14.8±0.34^{abc}	14.5±0.34^{bc}	15.3±0.34^{ab}	13.9±0.40^{c}	15.8±0.40^{a}	14.9±0.40^{abc}	14.8±0.40^{abc}
Drum stick, %	15.0±0.29^{ab}	14.6±0.31^{abc}	15.2±0.31^{a}	14.3±0.31^{abc}	12.6±0.37^{e}	14.1±0.37^{bcd}	13.1±0.37^{de}	13.6±0.37^{cde}
Breast,%	27.8±0.65^{d}	30.9±0.70^{c}	30.6±0.70^{c}	30.0±0.70^{c}	38.6±0.82^{a}	33.7±0.82^{b}	36.2±0.82^{a}	37.4±0.82^{a}

Table 2: Logarithmic regression of cuts weights (y) on carcass weight (x) of all the experimental turkeys

Carcass cuts	N	R^2	A	b	SE	P
Neck	49	0.88	-1.249	0.995	0.052	0.000
Back	49	0.87	0.149	0.766	0.042	0.000
Wing tip	49	0.22	1.128	0.238	0.065	0.001
Middle wing	49	0.75	0.429	0.548	0.046	0.000
Drum matte	49	0.91	-0.276	0.763	0.035	0.000
Thigh	49	0.97	-0.763	0.983	0.025	0.000
Drum stick	49	0.96	-0.323	0.863	0.024	0.000
Breast	49	0.97	-1.433	1.246	0.032	0.000

carcass weights were not significantly variable among the two systems.

Neck and thigh cuts percentages were affected by sex, where male turkeys had higher percentages than female, however, sometimes these variations were not significant due to sex interactions with system of management alone or together with slaughter week. This was in agreement with Ramkrishana et al. (2012) who found higher percentage of neck in male turkeys.

Back, wing tip, middle wing, drum matte and drum stick percentages were significantly affected by slaughter age, where week 16 slaughter age groups showed higher percentages than their week 28 slaughter fellow mates. These results were in agreement with Lawrence and Fowler (1997) Majumdar et al. (2005) and Ramkrishana et al. (2012) who showed that the percentages of body parts like back, wing and neck declined when the age increased. The present study showed that the breast percentage for week 28 slaughter age groups were of significantly higher breast percentage than those slaughtered at week 16 of age. This result was in agreement with that of Summers and Spratt (1990) and Pragati et al. (2005). Aviagen Turkeys (2013) confirmed that the older the turkeys, the higher the percentage of breast meat and the heavier body weight had more breast meat than smaller one and as the turkeys got older the breast muscle increased in size.

The logarithmic regression coefficient (*b*) is the percentage increase of the dependent variable at each 1% increase of the independent variable. It was used to relate the carcass cut weight increase to the whole carcass weight increase (Khalafalla et al., 2010). The authors stated that when the value of *b* is less than 1, the organ or tissue weight increases at a lower rate than the whole body weight does. When the value of *b* is more than 1 then the organ or tissue weight increases at a higher rate than the whole body weight does, the difference in weights increase is significant ($P<0.05$) if the error of *b* is less than the difference between *b* and 1. The logarithmic regressions of the pooled data of carcass cuts weight (y) on carcass weight (x) are shown in Table 2. All the regressions were significant ($P<0.001$) and had coefficient of determinations (r^2) ranging between 0.75 and 0.97 except that of wing tip ($r^2 = 0.22$). Only the breast cut had regression coefficient more than 1 and the error of b is less than the difference between b and 1 (b-1). Only the neck and thigh cuts whose errors of b values were higher than the difference between b and 1. These results indicated that neck and thigh cuts weights increases in a rate not different from that of the whole carcass. The breast cut weight increase was significantly higher than that of the whole carcass weight and for each 1% increase of whole carcass weight the breast weight was increasing by 1.246%. The weights of the rests of carcass components were increasing in rates lower than 1% when the whole carcass weight increased by 1%. In this context, Lawrence and Fowler (1997) stated that body growth results from the differential growth of its different tissues. They also stated that bony tissues are early maturing whereas the muscles are late maturing, therefore, after maturity the latter tissues are the most variable with body weight. Aviagen Turkeys (2013) added that breast was one of the latest developing muscles in turkey. Similarly, Raji et al. (2010) stated that slaughtering turkeys at an earlier age tended to increase the amount of bone relative to muscle and fat, whilst slaughtering turkeys at older ages tended to increase the ratio of fat to muscle.

All regressions of cuts weights on carcass weight of turkeys slaughtered at 16 and 28 weeks of age, male and

Table 3: Logarithmic regression of cuts weights (y) on carcass weight (x) of the turkeys slaughtered at 16 and 28 weeks of age

	Slaughter week 16						Slaughter week 28						t	Sign
Carcass cuts	N	R^2	a	b	SE of b	p	N	R^2	a	b	SE of b	p		level
Neck	29	0.65	-1.239	0.993	0.140	0.000	20	0.71	-2.723	1.360	0.206	0.000	-0.624	NS
Back	29	0.79	-1.767	1.285	0.129	0.000	20	0.86	-1.001	1.049	0.102	0.000	0.492	NS
Wing tip	29	0.43	-1.636	0.987	0.219	0.000	20	0.66	-0.827	0.720	0.123	0.000	0.457	NS
Middle wing	29	0.63	-1.604	1.098	0.161	0.000	20	0.75	-0.337	0.736	0.101	0.000	0.708	NS
Drum matte	29	0.46	-0.204	0.743	0.154	0.000	20	0.83	-0.304	0.770	0.081	0.000	-0.055	NS
Thigh	29	0.77	-0.579	0.932	0.099	0.000	20	0.91	-0.247	0.855	0.064	0.000	0.192	NS
Drum stick	29	0.83	-0.904	1.020	0.090	0.000	20	0.89	-0.320	0.861	0.072	0.000	0.393	NS
Breast	29	0.70	0.096	0.832	0.104	0.000	20	0.92	-1.031	1.148	0.079	0.000	-0.737	NS

Table 4: Logarithmic regression of cuts weights (y) on carcass weight (x) of male and female turkeys

	Males						Females						t	Sign
Carcass cuts	N	R^2	a	b	SE of b	p	N	R^2	a	b	SE of b	p		level
Neck	25	0.94	-1.218	0.995	0.054	0.000	24	0.86	-0.710	0.843	0.072	0.000	0.427	NS
Back	25	0.91	0.016	0.802	0.054	0.000	24	0.79	0.550	0.658	0.072	0.000	0.405	NS
Wing tip	25	0.19	1.419	0.172	0.073	0.027	24	0.17	1.181	0.214	0.099	0.042	-0.101	NS
Middle wing	25	0.81	0.765	0.468	0.048	0.000	24	0.77	0.215	0.597	0.070	0.000	-0.376	NS
Drum matte	25	0.94	-0.349	0.782	0.042	0.000	24	0.83	-0.120	0.722	0.070	0.000	0.180	NS
Thigh	25	0.98	-0.782	0.985	0.030	0.000	24	0.96	-0.883	1.017	0.043	0.000	-0.117	NS
Drum stick	25	0.99	-0.139	0.816	0.020	0.000	24	0.94	-0.631	0.943	0.051	0.000	-0.474	NS
Breast	25	0.98	-1.531	1.268	0.040	0.000	24	0.96	-1.418	1.245	0.054	0.000	0.077	NS

Table 5: Logarithmic regression of cuts weights (y) on carcass weight (x) of turkeys reared under intensive and extensive systems

	Semi-intensive system						Extensive system							Sign
Carcass cuts	N	R^2	a	b	SE of b	p	N	R^2	a	b	SE of b	p	t	level
Neck	25	0.92	-1.153	0.968	0.061	0.000	24	0.87	-1.338	1.020	0.085	0.000	-0.136	NS
Back	25	0.89	-0.001	0.809	0.059	0.000	24	0.88	0.292	0.724	0.056	0.000	0.250	NS
Wing tip	25	0.03	1.714	0.087	0.100	0.391	24	0.48	0.665	0.357	0.080	0.000	-0.636	NS
Middle wing	25	0.64	0.706	0.477	0.075	0.000	24	0.84	0.212	0.603	0.056	0.000	-0.349	NS
Drum matte	25	0.91	-0.099	0.718	0.046	0.000	24	0.91	-0.412	0.797	0.054	0.000	-0.251	NS
Thigh	25	0.97	-0.728	0.973	0.037	0.000	24	0.97	-0.794	0.991	0.035	0.000	-0.067	NS
Drum stick	25	0.96	-0.222	0.837	0.034	0.000	24	0.97	-0.403	0.883	0.035	0.000	-0.176	NS
Breast	25	0.96	-1.590	1.284	0.053	0.000	24	0.98	-1.318	1.218	0.036	0.000	0.223	NS

female turkeys as well as reared under semi intensive and extensive systems are shown in Tables 3, 4 and 5, respectively. The results illustrated that the regression coefficients of carcass cuts of turkeys were not affected by week of slaughter, sex of turkeys or system of management. The results in Table 3 indicated that when the turkeys slaughtered at week 16 of age, only the back cut weight that increased in a rate of 1.285±0.129% for each 1% increase of the whole carcass weight, whereas when they were slaughtered at week 28 of age the breast weight increased by 1.148±0.079% for each of 1% increase of whole carcass weight. Whereas, for both sex groups (Table 4) and for both managerial systems groups (Table 5) the breast was the cut that excelled the whole carcass in the rate of weight increase. It is clear that only the slaughter age that altered the trend of the relative body growth rate of carcass cuts. This result was in consistent with the findings of Summers and Spratt (1990), Majumdar et al. (2005) and Pragati et al. (2005).

It can be concluded that slaughter age and sex have important role in altering the percentages of the carcass components. Also it was evident that the development of turkey's carcass weight depended mainly on the breast cut weight increase. Moreover, 28 week was the best age to obtain high carcass yield and the semi intensive system was better than the extensive system for profitable turkey industry in the Sudan.

Acknowledgements

This study was supported by a grant-in-aid from the Ministry of Higher Education and Scientific Research, Sudan. The authors greatly appreciated the assistance of DETASI Company who supplied fertile eggs and Tarig Razaz hatcheries for incubation and hatching of eggs.

References

Ali, M.A.M. 2008. Experimental methods in agriculture, 1st Ed. Chapter 11. Correlation and regression. Currency Printing Press, Khartoum, Sudan, pp: 207-232.

Aviagen Turkeys, 2013. Factors affecting breast meat yield in turkeys. *Technical Advice Sheet*, Aviagen Turkeys Ltd. www.Aviagenturkeys.com.

British United Turkeys (BUT) 2005. Commercial performance goals, 5th Ed. British United Turkeys Ltd., Warren Hall, Broughton, UK

Castellini, C., Mugnai, C. and Dal Bosco, A. 2002. Effect of organic production system on broiler carcass and meat quality. *Meat Science*, 60: 219-225.

Gibril, S., Hassan, A.A., Yassin, O.E. and Shamseldin, R.M. 2013a. Growth performance and carcass characteristics of turkeys (*Meleagris gallopavo*) under semi intensive system in the Sudan. *University of Khartoum Journal of Agricultural Sciences*, 21: 99-115.

Gibril, S., Shamseldin, R.M., Yassin, O.E., Hassan, A.A. and Atta, M. 2013b. Body Gain and Carcass Characteristics of turkeys (*Meleagris gallopavo*) under extensive system of management in the Sudan. *International Journal of Applied Poultry Research*, 2: 23-26.

Gordon, S.H. and Charles, D.R. 2002. Niche and organic chicken products, Nottingham University Press, Nottingham, UK.

Isguzar, E. 2003. Growth, carcass traits and meat quality of Bronze and White turkeys in Isparta province of Turkey. Turkey. *Archiv Tierzucht Dummerstorf, Archives Animal Breeding*, 46: 473-481 (http://arch-anim-breed.fbn-dummerstorf.de/pdf/2003/at03p471.pdf).

Jensen, J.F. 1983. Method of dissection of broiler carcasses and description of parts. 1st Ed. Papworth's Pendragon Press, Cambridge, UK.

Khalafalla, I.E.E., Atta, M., Eltahir, I.E. and Mohammed, A.M. 2010. Effect of slaughter weight on growth of wholesale cuts of Sudan Western Baggara bull carcass. *Animal Science Journal*, 1: 23-27.

Khosravania, H., Murphy, N.H.N. and Govindaiah, M.G. 2006. Imposing restriction in selection for disproportionate cut-up carcass yield in an experimental flock of broiler chicken. *Journal of Poultry Science*, 43: 109-119.

Lawrence, T.L. and Fowler, V.R. 1997. Growth of farm animals. CAB International, Wallingford, Oxon, UK.

Majumdar, S., Bhanja, K., Singh, R.P. and Agarwal, S.K. 2005. Effect of age on the carcass traits and meat quality of turkey poults. *Journal of Applied Animal Research*, 27: 85-88

Pragati, H., Kondaiah, N., Mandal, B.B. and Saikia, P. 2005. Effect of age on yield of cut-up-parts and carcass components in broilers. IPSACON, Poultvet.Com, http://www.poulvet.com/poultry/articles/tech_products/23.php.

Raji, A.O., Igwebuike, J.U. and Kwari, I.D. 2010. Regression models for estimating breast, thigh and fat weight and yield of broilers from non invasive body measurements. *Agriculture and Biology Journal of North America*, 1: 469-475

Ramkrishana, R.S., Sheriff, F.R. and Manohar, G.R. 2012. Growth Performance and carcass yields as influenced by age and sex in different turkey varieties. *Tamilnadu Journal of Veterinary and Animal Sciences*, 8: 94-100.

Roberson, K.D., Kalbfleisch, J.L. and Dransfield, D. 2004. Comparison of growth performance and carcass component yield of a new strain of tom turkeys to other commercial strains. *International Journal of Poultry Science*, 3: 791-795.

StatSoft Inc, 2010. STATISTICA (data analysis software system), version 9.1. www.statsoft.com

Summers, J.D. and Spratt, D. 1990. Weight gain, carcass yield, and composition of large white male turkeys reared to 28 weeks of age on growing and finishing diets with varying levels of dietary protein. *Poultry Science*, 69: 584-591.

Wanger, J.R., Schinckel, A.P., Chen, W., Forest, J.C. and Coe, B.L. 1999. Analysis of body composition changes of swine during growth and development. *Journal of Animal Science*, 77: 1442-1466

Zerehdaran, S., Vereijken, A.L.J., van Arendonk, J.A.M. and van der Waaij, E.H. 2004. Estimation of genetic parameters for fat deposition and carcass traits in broilers. *Poultry Science*, 83: 521-525.