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Overview of chicken taxonomy and domestication

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Chickens are the most popular poultry worldwide and are now used for both meat and egg production. There is only a sporadic information in the literature on chicken taxonomy; and there is a lack of a single concise document that deals with different issues related to this important topic. The present document contains detailed information on the tree taxonomy of chickens. In addition, process of domestication and its effect on chicken genetic diversity, physiology and behaviour are also discussed. The major conclusions are as follows: 1) Chickens are classified as: order: Galliformes, family: Phasianidae, genus: *Gallus* (junglefowl). Four species of junglefowl are recognized. These are: a) *Gallus gallus* (red junglefowl), b) *Gallus varius* (green junglefowl), c) *Gallus sonneratii* (grey junglefowl) and d) *Gallus lafayetii* (Ceylon junglefowl). The current chickens that are used for both meat and egg production commercially are domesticated fowl and are the descendants of the red junglefowl species. 2) Domestication process is a complicated one and involves intensive breeding and selection programmes. During this process, genetic diversity is still maintained, yet reduced, so careful attention is needed in the future to maintain the diversity of specialized chicken species. 3) Domestication resulted in basic changes in the behaviour, physiology and production of the bird, but still there are some similarities between the ancestor and the current chickens.

Keywords: chicken taxonomy; junglefowl; domestication; domesticated fowl

Introduction

The current poultry is a domesticated fowl used for both meat and egg production. This includes birds such as chicken, turkey, duck, goose, ostrich, quail, pheasant, guinea fowl, and peafowl. Chickens are the most popular poultry worldwide irrespective of culture and religion (Roenigk, 1999; Aho, 2001; Aho, 2004). This is because poultry products have very high nutritive values. Chicken meat and eggs are the major protein source for consumers in most of the countries around the world. Chicken meat consumption has been increasing during the last few years due to the rise in health awareness of consumers all

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over the world. Broilers dominate the world poultry market, consisting of about 70% of the market. Turkeys account for about 8% and other poultry provides 22% of the global market (Roenigk, 1999; 2004; USDA, 2006). This indicates that broiler meat continues to be desired over other poultry meats.

All commercial chickens are the descendents of the red junglefowl species (Crawford, 1990a; Sullivan, 1991; Siegel *et al.*, 1992; Fumihito *et al.*, 1994; Romanov and Weigend, 2001; Hillel *et al.*, 2003; Vaisanen *et al.*, 2005). The taxonomy of these species will be reported later in this text. Historically, chickens were kept for cockfighting until mid-1800 when cockfighting became illegal, thereafter, poultry breeders in USA and Europe started to breed chickens for exhibition (Moreng and Avens, 1985; Crawford, 1990b). They were selected for uniformity and coloured plumage patterns. These efforts were important in the development of the standard breeds and varieties of chickens that were used in the development of commercial chickens of today. Standard breeds were classified in four major classes according to the place of origin, such as American, Asiatic, English, and Mediterranean classes. Each class is further subdivided into varieties and strains. Breeds that have major contributions in poultry meat production are Plymouth Rock (American class) and the Cornish (English class), and white Leghorn (Mediterranean class) is the major breed for table egg production (Moreng and Avens, 1985; North and Bell, 1990; APA, 2001a-c). The Plymouth Rocks were used because of their body conformation, on the other hand, Leghorns were used for their high egg production. Throughout the years chickens have been changed by natural and artificial selections in the process toward domestication. It is of great importance to have available a document that includes in details the chicken taxonomy and the process of domestication that led to the current chicken used in the poultry industry, to better understand the origin of the current chickens. Such a document is currently not available. Therefore, the main objective of the present paper is to discuss the chicken taxonomy and the process of domestication that started with the junglefowl.

Chicken taxonomy

Taxonomy from Greek verb *tassein= "to classify"* and *nomos* meaning law or science; so taxonomy refers to the science of classifying living things. Taxonomy deals with finding, describing and naming organisms. Taxonomies are hierarchical in structure, which is a tree structure of classifications for a given set of objects. The best known taxonomies are the ones developed by the Swedish scientist, Carl Linnaeus, whose classification for biology is still widely used with modifications. Linnaean taxonomy classifies living things into a hierarchy, originally starting with kingdoms. Today, some biologists consider Domains (Eukarya, Bacteria, Archaea) to be a classification above Kingdoms. So the structure of classification includes the Domain, Kingdom, Phylum, Class, Order, Family, Genus, and Species, with various other ranks sometimes inserted such as sub-class, and sub-species (Wikipedia, 2006). Chicken's classification/taxonomy (USDA/ITIS, 2006 a-j; Wikipedia, 2006; Wikispecies, 2006) is shown in *Figure 1*.

Chickens are classified as order Galliformes, family Phasianidae, genus *Gallus* (junglefowl) which is distinguished from all other phasianidae species in having the comb and the wattles associated with it (Crawford, 1990a; USDA/ ITIS, 2006 a-j). It is important to select such criteria to maintain differences from other species. Four species of junglefowl are recognized. These are: 1) red junglefowl, 2) grey junglefowl, 3) green junglefowl and 4) Ceylon junglefowl. There are no sub-species for grey, green or Ceylon junglefowl. However, geographic variation is very marked in red junglefowl and this has been recognized by designating several sub-species for red junglefowl (Moreng and

Avens, 1985; Crawford, 1990a; Collias and Collias, 1996; Moiseyeva *et al.*, 2003; USDA/IT IS, 2006a-j; Wikipedia, 2006; Wikispecies, 2006). The geographic variation implies the adaptation of the different sub-species to certain environmental conditions.

Species nomenclature has undergone some changes. Red junglefowl was called G. *bankiva* and G. *ferrugineus.* The Ceylon junglefowl was named G. *stanleyi*, and the green junglefowl was named G. *furcatus* (Crawford, 1990a).

It should be noted that classification of animals and plants was based on morphological, geographical and behavioural characteristics. The taxonomy and classification were done before the development of sequencing and molecular techniques (Bush and Strobeck, 2003; Wikipedia, 2006). Bush and Strobeck (2003) investigated phylogenetic relationships of the Phasianidae. They used nucleotide sequences from the mitochondrial cytochrome *b* gene of 27 pheasants and 6 non-pheasant species. They found that red junglefowl is located outside the pheasant lineage between the grey peacock (*Polyplectron bicalcaratum*) and the koklass (*Pucrasia macrolopha macrolopha*). The authors concluded that it is unclear whether the grey peacock, red junglefowl or koklass are pheasants, and since their respective positions were unstable it cannot be ruled out that they are pheasants. More studies and research in this subject is suggested using all the different species of junglefowl. It is clear that the science of molecular genetics will be fully utilized to provide more accurate classification to the different sub-species.

GALLUS GALLUS (Red Jungle Fowl)

Red junglefowl is the common name of the *Gallus gallus* species (*Figure 2*). The red junglefowl still can be found in India, China, Java, Malaysia, Indonesia and the Philippine. The red junglefowl has the largest natural range among the four species of the junglefowls. There are marked geographic variations recognized by its division into several subspecies. Most literature recognized only five subspecies of red junglefowl based on geographic variation, which are as follows: 1) Cochin-Chinese or Indochina red junglefowl; *Gallus gallus gallus* (*Figure 3*), 2) Javan red junglefowl; *Gallus gallus bankiva*, (*Figure 4*) 3) Tonkinese red junglefowl; *Gallus gallus jabouillei* (*Figure 5*), 4) Indian red junglefowl; *Gallus gallus murghi* (*Figure 6*) and 5) Burmese red junglefowl; *Gallus gallus spadiceus* (*Figure 7*) (Crawford, 1990a; Collias and Collias, 1996; Moiseyeva *et al.*, 2003; USDA/ITIS, 2006a-g). These five subspecies vary in size of facial wattles and combs and length and colour of the neck hackles in males (Cowell, 2006a). In recent literature, four more sub-species were considered (Wikispecies, 2006). These are *Gallus gallus domesticus* which is the one that the domestic fowl was developed from (Moreng and Avens, 1985; Sullivan, 1991; Siegel *et al.* 1992; Fumihito *et al.*, 1994; Romanov and Weigend, 2001; Hillel *et al.*, 2003; Vaisanen *et al.*, 2005; Columbia Encyclopedia, 2006). The other three sub-species are considered as feral *G. gallus* since they were successfully introduced in many places such as the Philippines, Micronesia, Melanesia and Polynesia (Crawford, 1990a). These were considered in some literature as subspecies and were added to the list of the red junglefowl subspecies as follows: *Gallus gallus gallina, Gallus gallus micronesiae*, and *Gallus gallus philippenisis* (Wikispecies, 2006).

Red junglefowl habitat varies and they used most types of forests in Southeast Asia, field edges, groves and scrubland. Breeding season is March through June. Clutch size is 5-6 eggs with an incubation period of 18-21 days (Cowell, 2006a). Physical description of red junglefowl is shown in *Table 1*. It is important to note that red junglefowl in the pure wild form is still uncommon in captivity. There are only few subspecies that are pure without any interbreeding from domestication or within the races (Cowell, 2006a; Gautier, 2006).

GALLUS VARIUS (green junglefowl)

Green junglefowl is the common name of this species (*Figure 8*), also it is known as the fork tail. It inhabits the island of Java. It is also found in Bali, Sumbawa, Komodo, Lombok and the surrounding islands. Green junglefowl also inhabits coastal regions and semi-arid cliff habitat and they forage in mangrove swamps, along beaches, in rice paddies and deep inside subterranean sea caves (Crawford, 1990a; Zanon, 2003). It is capable of sustained flight over open water. It has no sub-species (Blackwood, 2006a; Crawford, 1990a; USDA/ ITIS, 2006h; Zanon, 2003;). Its primary foods include species of semi-terrestrial crustaceans called copepods or sand fleas, small crabs and marine insects (Blackwood, 2006a; USDA/ITIS, 2006h). Breeding season is mid April to June. Clutch size is 5 to 10 eggs with incubation period of 21 days (Cowell, 2006b). Physical description of green junglefowl is shown in *Table 1*.

GALLUS SONNERATII (grey junglefowl)

Grey junglefowl is the common name of this species (*Figure 9*). It is native to southern and western India. It lives in mountain areas sometimes as high as 1500 – 2000 meters and it can easily fly. They feed on seasonal pulp seed fruits like pumpkin and hot peppers. It has no sub-species (Blackwood, 2006b; Crawford, 1990a; USDA/ ITIS, 2006i; Zanon, 2003). Breeding season is March to July. Clutch size is 4 to 6 eggs with incubation period of 21 days (Cowell, 2006c). Physical description of grey junglefowl is shown in *Table 1*.

GALLUS LAFAYETII (Ceylon Junglefowl)

The common name of this species is Ceylon junglefowl (*Figure 10*). It is endemic to Sri Lanka in Ceylon Island. It has no sub-species (Crawford, 1990a; Zanon, 2003; Cowell, 2006d; USDA/ ITIS, 2006j). It is considered as Sri Lanka national bird and is widely spread throughout the Island. It is known in Sinhala as Wali Kukula and Katu Koli in Tamil (Jayawardene, 2006). These birds fly only when it is necessary and roost at night. They feed on small fruits, berries, termites and other insects which they find on the forest floor. It is seen regularly in forest areas (Crawford, 1990a; Jayawardene, 2006). Breeding season varies on climates generally begins in April and lasts through June. Clutch size 3–6 eggs with an incubation period of 20-21 days (Cowell, 2006d). Physical description of Ceylon junglefowl is shown in *Table 1*.

Domestication and genetic diversity

Domestication is a process where a wild organism is habituated to survive in the company of human beings. It involves adaptation of animals to environmental conditions, therefore, some changes in behaviour and physiology of the animal would be expected (Siegel and Dunnington, 1990; Wikipedia, 2006). As reported, these behavioural and physiological changes associated with domestication is a must, however, these changes vary according to type of domestication whether it is toward meat or egg production. Archaeological discoveries in China indicate that chickens had been domesticated by 5400 B.C.; but it is not known whether these birds made much contribution to the modern domestic fowl. Chickens from Harappan culture of the Indus Valley (2500-2100 B.C.) may have been the main source for diffusion through the world (Crawford, 1990a and b). Birds were first domesticated for cultural and entertainment purposes, until much later birds were utilized as a source for human food (Crawford, 1990b). It is therefore expected that the physiological and behavioural changes occurred for adaptation to entertaining purposes are different from adaptation for human food.

Domestication process resulted in some differences and similarities between domestic

chicken and its ancestor the red junglefowl (Lindqvist *et al.*, 2002; Vaisanen and Jensen 2003; Vaisanen and Jensen 2004; Weeks and Nicol, 2006). This partially could be due to differences in their genetic makeup. These commercial egg and meat stocks are believed to exhibit heterosis and are available throughout the world (Hunton, 1990). However, the potential loss of genetic diversity is of great concern for most scientists and to the poultry industry due to the concentration of breeding programmes under the control of few large poultry organizations. Several studies were conducted to investigate the genetic diversity of the poultry stocks available in the world. Siegel *et al.* (1992), estimated the genetic distances among the breeding stocks to evaluate the genetic diversity. They reported that there is still a considerable amount of genetic diversity among chicken populations overall, but specialized types of fowl such as meat type and egg type have suffered of reduced diversity and increased similarity. These results indicate that concerns about reduced genetic diversity in highly selected populations may be well founded and attention must be given to prevent further losses in genetic diversity. On the other hand, Dunnington *et al.* (1994) used DNA fingerprinting technique to evaluate genetic diversity in elite pure lines of commercial broilers and layers. They found that the broiler sire, broiler dam, and parental lines that compose the majority of commercial breeder populations available in the USA contain a considerable reservoir of genetic diversity. Again the concern over loses in genetic diversity still remains.

Origin of domestic fowl

Chickens were originated as junglefowl in Asia and were domesticated over 3000 years ago, and are known now as chicken; *Gallus gallus domesticus* (Moreng and Avens, 1985; Crawford, 1990a; Sullivan, 1991; Siegel *et al.*, 1992; Fumihito *et al.*, 1994; Romanov and Weigend, 2001; Hillel *et al.*, 2003; Vaisanen *et al.* 2005, Columbia Encyclopedia, 2006). There was a debate on whether the domestic fowl is monophyletic or polyphyletic origin (Crawford, 1990a). It was indicated by many research studies that the red junglefowl is the direct ancestor of the domestic chicken (*Gallus gallus domesticus*) used in commercial production for meat and eggs (Moreng and Avens, 1985; Crawford, 1990a; Sullivan, 1991; Siegel *et al.*, 1992; Fumihito *et al.*, 1994; Romanov and Weigend, 2001; Hillel *et al.*, 2003; Vaisanen *et al.*, 2005; Columbia Encyclopedia, 2006). Fumuhito *et al.* (1994) reported that *G. g. gallus* of the red junglefowl is the origin of all domestic breeds. Collias and Collias (1996) reported that the red junglefowl is the principal and perhaps the sole ancestor of the domestic fowl. Moreover, the use of molecular genetics and micro-satellite techniques provided evidence that the origin of domestic fowl is monophyletic. Hillel *et al.* (2003) evaluated the gene pool of 52 chicken populations from a wide range of origins using the micro-satellite markers technique. They found that the red junglefowl is the main progenitor of the domestic chickens.

Moiseyeva *et al.* (2003) investigated the similarity and evolutionary relationships between *G. gallus* and different chicken breeds. The authors conducted four experiments on genetic relationships using different estimation criteria including morphological discrete characters, body measurements, biochemical markers, and the activity of serum esterase-1. They found that the greatest similarity was found between *G. gallus* and egg type breeds of Mediterranean roots and / or true Bantam. In addition Collias and Collais (1996) reported that Leghorn breed is very similar to the red junglefowl. Therefore, all in all it seams that the domesticated chickens are from one origin.

Behavioural and physiological changes

Intensive selective breeding programmes were used to improve egg production of junglefowl from 10 to 15 eggs per year in the wild to more than 300 eggs per year in the current laying hen (Moreng and Avens, 1985; Romanov and Weigend, 2001). These programmes resulted in some behavioural and physiological changes in the domesticated fowl, which are expected since chickens are adapted to more protected environment in which some natural behaviours are not necessarily needed (Weeks and Nicol, 2006). In addition, in order to increase egg production to that high level, changes in the endocrine system and hormone production is needed. Behavioural changes such as the tendency of Leghorns to invest its energy for production by decreasing its time in roaming and exploration, while junglefowls tend to be more explorative than Leghorns, which is natural behaviour needed for food security, have been realized (Lindqvist *et al.*, 2002; Schutz *et al.*, 2002; Vaisanen and Jensen 2003; Vaisanen and Jensen 2004). Redistribution of energy to meet changing needs is a common phenomenon within the different species. Leghorns tend to cope more in familiar environment, prefer smaller group size to know each other, and had less ability to cope with group disruption in comparison with junglefowl (Vaisanen and Jensen 2004; Vaisanen *et al.*, 2005; Weeks and Nicol, 2006). Impaired learning capacity of Leghorns was reported as compared to junglefowl which showed faster social learning ability (Lindqvist *et al.*, 2002; Vaisanen and Jensen 2004). However, Vaisanen *et al.* (2005) reported that the repertoire of social signals including aggressiveness and courtship behaviour has been preserved to a large extent during domestication with only few changes in frequencies and intensities. Foraging behaviour is shown by junglefowl which is adaptive to natural environment, and was found to be reduced in modern breeds, but it is also reported as needed behaviour for laying hens (Lindqvist *et al.*, 2002; Weeks and Nicol, 2006). It is worth mentioning that the social organization such as dominance and pecking order is maintained in the chickens (Cllias and Collias, 1996; Vaisanen *et al.*, 2005).

In addition, the process of domestication was associated with some physiological changes. Wideman *et al.* (1998) reported that male giant junglefowl (12-13 weeks old), maintained a lower respiratory rate, superior arterial blood gas values, but similar hematocrit when compared with 6 weeks old male broilers. Also, the giant red junglefowl weighed less than broilers and had equivalent absolute values for pulmonary arterial pressure, cardiac output, and pulmonary vascular resistance. In addition, Wall and Anthony (1995) compared carcass characteristics of giant junglefowl and broiler breeders and the respective F1 cross between them when processed at a common body weight. It was also found that the junglefowl had more deboned leg muscle, less *Pectoralis major* muscle, lower organ weights less abdominal fat, and the digestive tract weighed less and was shorter in length than broiler breeders (Wall and Anthony, 1995). However, in some instances domestication did not result in physiological changes. Janes and Braun (1997) reported that the red junglefowl exhibit urinary protein excretion similar to domestic fowl.

It should be mentioned that any physiological changes occurred during domestication is a necessary process of adaptation in order to phase new environmental and management conditions.

Development of the poultry industry

The development of the poultry industry from backyard production and into more specialized concentrated poultry companies took place in less than a century. This was done as a result of scientific achievements in poultry breeding and genetics, poultry

nutrition, housing, management and disease control (Hunton, 1990). Between the years 1930 and 1950, chickens were first selected and bred as pure breeds followed by crossbreeding. The number of breeds, varieties and strains used in poultry production declined and at the same time number of breeding companies was reduced. Currently, few international corporations supply most of the breeds to the international market (Crawford, 1990b; Dunnington *et al.*, 1994; Romanov and Weigend, 2001; Siegel *et al.*, 1992; Hillel *et al.*, 2003). Artificial selection was used in developing poultry with outstanding performance for the production of traits of economical importance such as meat and eggs. The breeds which currently dominate the world's poultry industry were all developed during the "hen craze" era (late 19th to early 20th centuries) (Crawford, 1990b; Dunnington *et al.*, 1994; Romanov and Weigend, 2001; Siegel *et al.*, 1992; Hillel *et al.*, 2003). Single comb white leghorn was used as the producer of the industrial white shelled eggs. Eggs with brown shells are commercially produced from crosses of several dual purpose breeds developed after 1850 and the major contributors were Plymouth Rocks, New Hampshire, Rhode Island Red and Australorp. Also, a strain of brown Leghorn was developed and is also producing brown eggs. Modern broilers are based heavily on crosses of Cornish and White Plymouth Rocks. The Cornish was developed in England from Asiatic fighting stocks, and the white Plymouth Rock was derived as a mutant of American parent breed (Crawford, 1990b; Siegel *et al.*, 1992; APA, 2001a-c).

Concluding remarks

It is clear from the present overview that the red junglefowl is the main ancestor of the current chickens. In addition it is also clear that there are more than one species for the junglefowl and more than one sub-species under the red junglefowl.

The process of domestication is a complicated one and involved many years of breeding and selection programmes. It is important to mention that even though throughout the process of domestication the genetic diversity is still maintained, yet reduced, careful attention is needed for the future specialized strains of chickens to avoid further reduction.

In addition, domestication process resulted in basic changes in the behaviour, physiology, and production of the bird, yet there are still some similarities between the ancestor bird and the current domesticated one.

References

AHO, P. (2001) The World's Commercial Chicken Meat and Egg Industries. *In:* Commercial Chicken Meat and Egg production. Fifth edition. (Ed. Bell, D. D., and Weaver W. D.). Kluwer Academic Publishers, the Netherlands, pp: 3-17.

AHO, P. (2004) Challenges and opportunities for marketing poultry products in developed and developing countries. Presented on behalf of The American Soybean Association in Romania and Turkey, June 1-16, 2004.

APA (2001a) Plymouth rock. *In:* American Standard of Perfection, pp: 40-45. 2001 edition, Published by American Poultry Association, Inc. Mendon, Massachusetts, USA.

APA (2001b) Cornish. *In:* American Standard of Perfection, pp: 96-99. 2001 edition, Published by American Poultry Association, Inc. Mendon, Massachusetts, USA.

APA (2001c) Leghorn. *In:* American Standard of Perfection, pp: 114-120. 2001 edition, Published by American Poultry Association, Inc. Mendon, Massachusetts, USA.

BLACKWOOD, K. (2006a) Green Junglefowl a.k.a Fork Tail *Gallus varius*. pp:1-3 www.feathersite.com/poultry/.

BLACKWOOD, K. (2006b) Grey (or sonnerat's) junglefowl *Gallus sonneratii*. pp: 1-8 www.feathersite.com/poultry/.

BUSH, K.L. and STROBECK, C. (2003) Phylogenetic relationships of the phasianidae reveals possible non-pheasant taxa. *Journal of Heredity* **94**(6): 472-489.

COLLIAS, N. and COLLIAS, E. (1996) Social organization of a red jungle fowl, *Gallus gallus,* population related to evolution theory. *The Association of the study of animal behaviour*, pp: 1337-1345.

COLUMBIA ENCYCLOPEDIA (2006) Poultry. *The Columbia Encyclopedia, sixth edition*. Columbia University Press. pp: 1-6, www.encyclopedia.com/html/p/poultry.asp

COWELL, D. (2006a) Red Junglefowl (*Gallus gallus*). gbwf.org PP:1-3.

COWELL, D. (2006b) Green Junglefowl (*Gallus varius*). gbwf.org PP: 1-3.

COWELL, D. (2006c) Grey Junglefowl (*Gallus sonnerati*). gbwf.org PP: 1-3.

COWELL, D. (2006d) Ceylon Junglefowl (*Gallus lafayattei*). gbwf.org PP: 1-2.

CRAWFORD, R.D. (1990a) Poultry Biology: Origin and History of Poultry Species. *In:* Poultry Breeding and Genetics (Ed. Crawford, R.D.). Elsevier Science Publishing Company, Amsterdam and New York, pp: 1-42.

CRAWFORD, R.D. (1990b) Poultry genetic resources: evolution, diversity, and conservation. *In:* Poultry Breeding and Genetics (Ed. Crawford, R.D.). Elsevier Science Publishing Company, Amsterdam and New York, pp: 43-60.

DUNNINGTON, E.A., STALLARD, L.C., HILLEL, J. and SIEGEL, P.B. (1994) Genetic diversity among commercial chicken populations estimated from DNA fingerprints. *Poultry Science* **73**:1218-1225.

FUMIHITO, A., MIYAKE, T., SUMI, S., TAKADA, M., OHNO, S. and KONDO, N. (1994) One subspecies of the red jungle fowl (*Gallus gallus gallus*) suffices as the matriarchic ancestor of all domestic breeds. *Proc. Natl. Acad. Sci. USA* **91**: 12505-12509.

GAUTIER, Z. (2006) *Gallus gallus* (red junglefowl). University of Michigan. The regents of the University of Michigan and its licensors PP:1-5. www.animaldiversity.ummz.umich.edu/site/accounts/information/gallus_gallus.html.

HILLEL, J., GROENEN, M.A., TIXIER-BOICHARD, M., KOROL, A.B., DAVID, L., KIRZHNER, V.M., BURKE, T., BARRE-DIRIE, A., CROOIJMANS, R.P., ELO, K., FELDMAN, M.W., FREIDLIN, P.J., MAKI-TANILA, A., OORTWIJN, M., THOMSON, P., VIGNAL, A., WIMMERS, K. and WEIGEND, S. (2003) Biodiversity of 52 chicken populations assessed by microsatellite typing of DNA pools. *Genetics, Selection, Evolution* **35**: 533-557.

HUNTON, P. (1990) Industrial breeding and selection. *In:* Poultry Breeding and Genetics, (Ed. Crawford R.D.). Elsevier Science Publishing Company, Amsterdam and New York, pp: 985-1028.

JANES, D.N. and BRAUN, E.J. (1997) Urinary protein excretion in red junglefowl (*Gallus gallus*). *Comparative Biochemistry and Physiology* **118A (5)**: 1273-1275.

JAYAWARDENE, J. (2006) Sri Lanka's Endemic Birds. Wild Life, Lake House. The associated Newspapers of Ceylon Ltd PP: 1-10 www.dailynews.lk/2006/04/10/fea10.asp.

LINDQVIST, C.E.S., SCHUTZ, K.E. and JENSEN, P. (2002) Red jungle fowl have more contra freeloading than white leghorn layers: effect of food deprivation and consequences for information gain. *Behaviour* **139**: 1195-1209.

MORENG, R. and AVENS, J.S. (1985) Classification, nomenclature, and showing of poultry. *In:* Poultry Science and Production. Reston Publishing Co., Inc. Prentice-Hall Company. Reston, Virginia 22090, pp: 16-45.

MOISEYEVA, I.G., ROMANOV, M.N., NIKIFOROV, A.A., SEVASTYANOVA, A.A. and SEMYENOVA, S.K. (2003) Evolutionary relationships of red jungle fowl and chicken breeds. *Genetics, Selection, Evolution* **35**: 403-423.

NORTH, M.O. and BELL, D.D. (1990) Modern Breeds of Chickens. *In:* Commercial Chicken Production Manual. Fourth edition. An AVI Book, Van Nostrand Reinhold 115 Fifth Avenue new York, New York 10003, pp: 1-12.

ROENIGK, W.P. (1999) World poultry consumption. *Poultry Science* **78**: 722-728.

ROMANOV, M.N. and WEIGEND, S. (2001) Analysis of genetic relationships between various populations of domestic and jungle fowl using microsatellite markers. *Poultry Science* **80**: 1057-1063.

SCHUTZ, K., KERJE, S., CARLBORG, O., JACOBSSON, L., ANDERSSON, L. and JENSEN, P. (2002) QTL analysis of a red junglefowl X white leghorn intercross reveals trade-off in resource allocation between behavior and production traits. *Behavior Genetics* **32(6)**: 423-433.

SIEGEL, P.B. and DUNNINGTON, E.A. (1990) Behavioral genetics. *In:* Poultry Breeding and Genetics (Ed. Crawford R.D.). Elsevier Science Publishing Company, Amsterdam and New York, pp: 877-896.

SIEGEL, P.B., HABERFELD, A., MUKHERJEE, T.K., STALLARD, L.C., MARKS, H.L., ANTHONY, N.B. and DUNNINGTON, E.A. (1992) Jungle fowl – domestic fowl relationships: a use of DNA fingerprinting. *World's Poultry Science Journal* **48**: 147-155.

SULLIVAN, M. (1991) Flock structure in red junglefowl. *Applied Animal Behaviour Science* **30**: 381-386.

USDA (2006) Livestock and Poultry: World Markets and Trade. March 2006 data, pp:17-26 (fas.usda.org/).

USDA/ ITIS (2006a) *Gallus* (Brisson, 1760), Taxonomy and Nomenclature. ITIS standard report page. Taxonomic Serial No. 176085 (Itis.usda.gov).

USDA/ ITIS (2006b) *Gallus gallus* (Linnaeus, 1758), Taxonomy and Nomenclature. ITIS standard report page. Taxonomic Serial No. 176086 (Itis.usda.gov).

USDA/ ITIS (2006c) *Gallus gallus gallus* (Linnaeus, 1758), Taxonomy and Nomenclature. ITIS standard report page. Taxonomic Serial No. 678002 (Itis.usda.gov).

USDA/ ITIS (2006d) *Gallus gallus jabouillei* (Delacour & Kinnear, 1928),Taxonomy and Nomenclature. ITIS standard report page. Taxonomic Serial No. 678003 (Itis.usda.gov).

USDA/ ITIS (2006e) *Gallus gallus murghi* (Robinson & Kloss, 1920), Taxonomy and Nomenclature. ITIS standard report page. Taxonomic Serial No. 678004 (Itis.usda.gov).

USDA/ ITIS (2006f) *Gallus gallus spadiceus* (Bonnaterre, 1792), Taxonomy and Nomenclature. ITIS standard report page. Taxonomic Serial No. 678005 (Itis.usda.gov).

USDA/ ITIS (2006g) *Gallus gallus bankiva* (Temminck, 1813), Taxonomy and Nomenclature. ITIS standard report page. Taxonomic Serial No. 678001 (Itis.usda.gov).

USDA/ ITIS (2006h) *Gallus varius* (Shaw, 1798), Taxonomy and Nomenclature. ITIS standard report page. Taxonomic Serial No. 176089 (Itis.usda.gov).

USDA/ ITIS (2006i) *Gallus lafayetii* (Lesson, 1831), Taxonomy and Nomenclature. ITIS standard report page. Taxonomic Serial No. 553881 (Itis.usda.gov).

USDA/ ITIS (2006j) *Gallus sonneratii* (Temminck, 1813), Taxonomy and Nomenclature. ITIS standard report page. Taxonomic Serial No. 176088 (Itis.usda.gov).

VAISANEN, J., HAKANSSON, J. and JENSEN, P. (2005) Social interactions in red junglefowl (*Gallus gallus*) and white leghorn layers in stable groups and after re-grouping. *British Poultry Science* **46** (2): 156-168.

VAISANEN, J. and JENSEN, P. (2003) Social versus exploration and foraging motivation in young red jungle fowl (*Gallus gallus*) and white leghorn layers. *Applied Animal Behaviour Science* **84**: 139-158.

VAISANEN, J. and JENSEN, P. (2004) Responses of young red jungle fowl (*Gallus gallus*) and white leghorn layers to familiar and unfamiliar social stimuli. *Poultry Science* **83**: 335-343.

WALL, C.W. and ANTHONY, N.B. (1995) Inheritance of carcass variables when giant jungle fowl and broilers achieve a common physiological body weight. *Poultry Science* **74**: 231-236.

WEEKS, C.A. and NICOL, C.J. (2006) Behavioural needs, priorities and preferences of laying hens. *World's Poultry Science Journal* **62**: 296-307.

WIDEMAN, R.F., FORMAN, M.F., HUGHES, J.D., KIRBY, Y.K., MARSON, N. and ANTHONY, N.B. (1998) Flow-dependant pulmonary vasodilation during acute unilateral pulmonary artery occlusion in jungle fowl. *Poultry Science* **77**: 615-626.

WIKIPEDIA (2006) Domestication. pp: 1-7 www.wikipedia.org/wiki/chicken.

WIKISPECIES (2006) Taxonavigation. pp: 1-2 www.species.wikimedia.org/wiki/gallus_gallus.

ZANON, A. (2003) Chickens *Gallus gallus.* Pollaiodelre,com ilpollaiodelre.com, pp: 1-17. www.ilpollaiodelre.com.

Table 1 Physical description of Junglefowl species.

Species	Physical Description	References
Gallus gallus	Red Junglefowl. The female fowl plumage is dull brown gold colour. The male is more coloured in combination of gold, red, brown, dark maroon, orange, with a bit of metallic green and grey. The Red Junglefowl can measure up to 70 cm in length. They have a total of fourteen tail feathers that can be almost 28 cm in length.	Crawford, 1990a; Zanon, 2003; Cowell, 2006a; Gautier, 2006.
	The comb is single upright serrated blade associated with a pair of wattles.	Crawford, 1990a
	During summer, the males exhibit an eclipse plumage in which the black and tan striped hackles and neck hackles are replaced by regular shaped hen like feathers of a soot black colour.	Crawford, 1990a; Zanon, 2003).
Gallus varius	Green Junglefowl. The cock's head, neck and upper rump is covered with rather short, abruptly ending feathers, black at the base, with a shade, blue in the centre and golden green on the remaining surface. Lower part of the rump is golden green with blue sheen, gradually turning into a purple shaded brass at the outer ends.	Crawford, 1990a; Zanon, 2003.
	Saddle and tail coverts and hackles are black with golden yellow thin edging. Lower and middle wing coverts are red orange in colour with a long central black stripe; primaries and primary coverts are black with a slight greenish blue shade.	Crawford, 1990a; Zanon, 2003.
	Abdomen and tail are also black with a light greenish blue shade. This species does not undergo any seasonal moult (eclipse plumage) in the neck's feathers	Crawford, 1990a; Zanon, 2003.
	The hen is brownish in colour. The hens comb and wattles are scarcely developed, the male comb is unserrated and multicoloured with one median wattle.	Crawford, 1990a; Zanon, 2003.
Gallus sonneratii	Grey Junglefowl The cock's feathers on the head, neck and forepart of the rump are black, with grey fringes. The remaining part of the saddle and rump, including the marginal wing coverts are purple shaded, with grey edging and a thin white stripe along the shaft; the main saddle feathers display orange and red fringes and are embellished with yellow flame shaped spots in the apex. Primaries and primary coverts are brown-black.	Crawford, 1990a
	Abdomen, lower parts of the body and keel are grey, with side hackles displaying reddish fringes in their apex. Tail is black with green sheen.	Crawford, 1990a
	The male exhibits eclipse plumage after the breeding season.	Crawford, 1990a
	The hen's comb is extremely small while the male comb is a single upright serrated blade with a pair of wattles.	Crawford, 1990a; Zanon, 2003.
Gallus lafayetii	Ceylon Junglefowl. The male is very pretty, and exhibits an eclipse plumage after the breeding season. The male comb is a single upright serrated blade with a pair of wattles.	Crawford, 1990a
	The cock has orange reddish head, golden plumage with black stripes in length. Saddle feathers are purple red at the base, with a bluish colour at their apex. Tail is black with blue sheen.	Cowell, 2006d

Figure 1. Chicken classification and taxonomy.

Domain:	Eukarya
Kingdom:	Animalia
Phylum:	Chordata
Subphylum:	Vertebtata
Class:	Aves
Order:	Galliformes
Family:	Phasianidae
Subfamily:	Phasianinae
Genus:	*Gallus* (Brisson, 1760)
Species:	G*allus gallus* (Linnaeus, 1758)
Sub-species:	*Gallus gallus gallus* (Linnaeus, 1758)
Sub-species:	*Gallus gallus spadiceus* (Bonnaterre, 1792)
Sub-species:	*Gallus gallus bankiva* (Temminck, 1813)
Sub-species:	*Gallus gallus murghi* (Robinson & Kloss, 1920)
Sub-species:	*Gallus gallus jabouillei* (Delacour & Kinnear, 1928)
Sub-species:	*Gallus gallus domesticus*
Sub-species:	*Gallus gallus gallina*
Sub-species:	*Gallus gallus micronesiae*
Sub-species:	*Gallus gallus philippenisis*
Species:	*Gallus varius* (Shaw, 1798)
Species:	*Gallus sonneratii* (Temminck, 1813)
Species:	*Gallus lafayetii* (Lesson, 1831)

Figure 2 Gallus gallus (Red Jungle Fowl). http://www.thailandbirding.com/red-jungle-fowl.jpg

Figure 3 Gallus gallus gallus (Cochin-Chinese or Indochina Red Junglefowl). http://www.orientalbirdimages.org/

Figure 4 Gallus gallus bankiva (Javan Red Junglefowl). http://www.notason.com/oiseaux/c3f5ec80.jpg

Figure 5 Gallus gallus jabouillei (Tonkinese Red Junglefowl). http://www.ilpollaiodelre.com/i_polli.htm

Figure 6 Gallus gallus murghi (Indian Red Junglefowl). http://www.orientalbirdimages.org/

Figure 7 Gallus gallus spadiceus (Burmese Red Junglefowl). http://www.orientalbirdimages.org/

Figure 8 Gallus varius (Green Junglefowl). http://www.stevenrotsch.com/National%20aviary%202006

Figure 9 Gallus sonneratii (Grey Junglefowl). http:/www.kalyanvarma.net/grey_jungle_fowl_239.jpg

Figure 10 Gallus lafayetii (Ceylon Junglefowl). http://www.worldbirder.com/photo/photos/1990.jpg