Addendum A 1

Allele frequencies estimated for all populations tested

Allele frequencies in 9 populations

Locus	Population								
	KK	**NH**	**NN**	**LV**	**OV**	**AU**	**BS**	**MS**	**ZM**
adl 268									
N	17	13	14	34	36	18	13	14	14
A	.059	.000	.000	.000	.000	.000	.000	.000	.000
B	.000	.154	.000	.044	.069	.000	.000	.036	.000
C	.000	.000	.250	.441	.167	.194	.000	.000	.679
D	.000	.308	.321	.250	.111	.111	.308	.571	.000
E	.000	.154	.107	.221	.319	.278	.192	.000	.071
F	.647	.346	.286	.044	.292	.222	.346	.250	.000
G	.235	.038	.036	.000	.042	.000	.154	.107	.000
H	.059	.000	.000	.000	.000	.083	.000	.000	.000
I	.000	.000	.000	.000	.000	.000	.000	.036	.000
J	.000	.000	.000	.000	.000	.111	.000	.000	.250
MCW 67									
N	37	36	31	39	38	22	12	16	18
A	.000	.000	.048	.000	.000	.000	.000	.000	.000
B	.000	.028	.048	.000	.000	.000	.000	.000	.000
C	.000	.000	.000	.000	.013	.000	.000	.000	.000
D	.000	.000	.016	.000	.000	.000	.000	.000	.000
E	.419	.042	.242	.141	.474	.227	.000	.000	.306
F	.500	.125	.403	.218	.289	.318	.292	.500	.167
G	.027	.069	.161	.128	.105	.000	.292	.250	.000
H	.054	.500	.016	.359	.053	.432	.000	.000	.500
I	.000	.236	.032	.128	.026	.000	.417	.250	.000
J	.000	.000	.032	.026	.013	.023	.000	.000	.028
K	.000	.000	.000	.000	.026	.000	.000	.000	.000
MCW 69									
N	50	47	44	34	27	25	13	16	20
A	.000	.021	.000	.000	.000	.000	.000	.000	.000
B	.000	.000	.011	.000	.000	.000	.000	.000	.000
C	.000	.000	.011	.000	.000	.000	.000	.000	.000
D	.130	.011	.409	.456	.426	.340	.000	.000	.375
E	.060	.085	.148	.353	.222	.000	.308	.250	.000
F	.020	.298	.125	.074	.000	.000	.000	.375	.075
G	.790	.363	.273	.059	.093	.560	.462	.219	.325
H	.000	.000	.011	.000	.259	.020	.038	.125	.000
I	.000	.000	.000	.000	.000	.020	.000	.000	.075
J	.000	.000	.000	.000	.000	.000	.077	.031	.000
K	.000	.000	.000	.000	.000	.000	.038	.000	.025
L	.000	.213	.011	.000	.000	.060	.000	.000	.125
M	.000	.011	.000	.029	.000	.000	.000	.000	.000
N	.000	.000	.000	.029	.000	.000	.077	.000	.000

Locus	Population								
	KK	**NH**	**NN**	**LV**	**OV**	**AU**	**BS**	**MS**	**ZM**
MCW 98									
N	46	22	41	27	23	3	13	16	14
A	.022	.000	.000	.000	.000	.333	.000	.000	.071
B	.272	.909	.488	.907	.435	.333	.615	.469	.679
C	.707	.068	.500	.056	.565	.333	.385	.531	.214
D	.000	.023	.012	.037	.000	.000	.000	.000	.036
MCW 103									
N	36	36	37	18	30	27	13	16	17
A	.000	.028	.000	.000	.000	.000	.000	.000	.000
B	.000	.000	.000	.000	.033	.000	.000	.000	.000
C	.000	.403	.514	.028	.017	.074	.000	.031	.147
D	.000	.000	.027	.000	.000	.000	.000	.000	.029
E	.556	.472	.297	.278	.567	.926	.115	.500	.824
F	.444	.097	.162	.639	.367	.000	.885	.469	.000
G	.000	.000	.000	.056	.017	.000	.000	.000	.000
MCW 111									
N	47	46	42	18	31	25	11	14	17
A	.032	.000	.000	.000	.000	.000	.000	.000	.000
B	.021	.000	.000	.000	.000	.000	.000	.000	.000
C	.000	.043	.000	.000	.000	.000	.000	.000	.000
D	.234	.011	.274	.028	.016	.180	.000	.000	.441
E	.330	.217	.238	.389	.597	.120	.182	.071	.500
F	.287	.489	.345	.361	.323	.700	.364	.607	.059
G	.064	.120	.060	.194	.065	.000	.227	.107	.000
H	.000	.000	.012	.000	.000	.000	.000	.036	.000
I	.011	.000	.000	.000	.000	.000	.091	.000	.000
J	.000	.033	.000	.000	.000	.000	.000	.000	.000
K	.000	.000	.000	.000	.000	.000	.136	.000	.000
L	.021	.087	.071	.000	.000	.000	.000	.000	.000
M	.000	.000	.000	.028	.000	.000	.000	.000	.000
MCW 183									
N	35	21	41	31	38	22	11	15	17
A	.000	.000	.000	.000	.013	.000	.000	.000	.029
B	.300	.095	.110	.113	.053	.477	.455	.300	.412
C	.000	.024	.012	.000	.000	.045	.091	.067	.118
D	.000	.000	.012	.000	.013	.000	.000	.000	.000
E	.000	.667	.646	.806	.092	.159	.091	.333	.176
F	.057	.024	.024	.032	.500	.159	.045	.167	.088
G	.000	.071	.012	.000	.013	.000	.000	.000	.000
H	.643	.119	.171	.049	.276	.091	.227	.133	.118
I	.000	.000	.012	.000	.000	.000	.000	.000	.000
J	.000	.000	.000	.000	.039	.068	.000	.000	.059
K	.000	.000	.000	.000	.000	.000	.045	.000	.000
L	.000	.000	.000	.000	.000	.000	.045	.000	.000

Locus	Population								
	KK	**NH**	**NN**	**LV**	**OV**	**AU**	**BS**	**MS**	**ZM**
MCW 216									
N	47	46	40	38	28	26	10	9	11
A	.021	.000	.000	.000	.000	.000	.050	.000	.000
B	.000	.174	.450	.329	.018	.000	.250	.000	.091
C	.340	.522	.363	.526	.107	.423	.200	.333	.545
D	.596	.304	.162	.145	.875	.538	.500	.556	.364
E	.021	.000	.000	.000	.000	.019	.000	.000	.000
F	.000	.000	.000	.000	.000	.000	.000	.056	.000
G	.000	.000	.000	.000	.000	.019	.000	.000	.000
H	.000	.000	.025	.000	.000	.000	.000	.000	.000
I	.021	.000	.000	.000	.000	.000	.000	.056	.000
MCW 248									
N	37	46	39	33	23	19	11	14	21
A	.554	.261	.372	.333	.326	.816	.000	.000	.881
B	.446	.239	.128	.470	.413	.184	.727	.714	.095
C	.000	.033	.244	.167	.196	.000	.000	.143	.000
D	.000	.054	.141	.030	.022	.000	.227	.107	.024
E	.000	.022	.013	.000	.043	.000	.045	.036	.000
F	.000	.054	.000	.000	.000	.000	.000	.000	.000
G	.000	.259	.064	.000	.000	.000	.000	.000	.000
H	.000	.022	.000	.000	.000	.000	.000	.000	.000
I	.000	.054	.038	.000	.000	.000	.000	.000	.000
J	.000	.011	.000	.000	.000	.000	.000	.000	.000
MCW 295									
N	41	13	28	35	33	18	13	14	9
A	.000	.000	.018	.000	.000	.000	.000	.000	.000
B	.354	.000	.125	.029	.212	.361	.000	.000	.611
C	.220	.000	.143	.386	.061	.028	.038	.000	.056
D	.232	.308	.036	.000	.061	.000	.385	.571	.000
E	.085	.423	.036	.086	.015	.000	.115	.071	.000
F	.110	.000	.304	.014	.106	.500	.000	.000	.278
G	.000	.000	.018	.071	.000	.111	.000	.000	.000
H	.000	.231	.089	.229	.242	.000	.308	.250	.056
I	.000	.038	.143	.171	.061	.000	.077	.071	.000
J	.000	.000	.089	.014	.000	.000	.000	.000	.000
K	.000	.000	.000	.000	.000	.000	.077	.036	.000
MCW 330									
N	31	31	36	31	30	11	12	16	18
A	.000	.000	.139	.000	.050	.045	.000	.000	.139
B	.000	.016	.000	.000	.017	.000	.125	.125	.000
C	.081	.000	.000	.097	.250	.318	.000	.000	.528
D	.016	.016	.028	.048	.150	.091	.292	.188	.000
E	.000	.000	.000	.000	.000	.045	.000	.000	.028
F	.323	.516	.500	.355	.200	.318	.000	.000	.139
G	.387	.306	.292	.177	.133	.000	.208	.406	.000
H	.000	.000	.014	.000	.000	.000	.000	.000	.000
I	.194	.145	.028	.323	.200	.136	.375	.281	.167
J	.000	.000	.000	.000	.000	.045	.000	.000	.000

Allele frequencies from additional microsatellite markers for group

Locus	Population						
	KK	NH	NN	LV	OV	BS	MS
adl 268							
N	17	13	14	34	36	13	14
A	.059	.000	.000	.000	.000	.000	.000
B	.000	.154	.000	.044	.069	.000	.036
C	.000	.000	.250	.441	.167	.000	.000
D	.000	.308	.321	.250	.111	.308	.571
E	.000	.154	.107	.221	.319	.192	.000
F	.647	.346	.286	.044	.292	.346	.250
G	.235	.038	.036	.000	.042	.154	.107
H	.059	.000	.000	.000	.000	.000	.000
I	.000	.000	.000	.000	.000	.000	.036
adl 278							
N	16	14	9	13	11	13	16
A	.094	.143	.167	.077	.182	.577	.250
B	.813	.643	.444	.654	.182	.269	.000
C	.094	.214	.389	.269	.636	.154	.464
MCW 14							
N	16	14	9	13	12	13	14
A	1.000	.321	.222	.154	.333	.308	.357
B	.000	.000	.000	.000	.000	.000	.179
C	.000	.036	.056	.000	.000	.038	.000
D	.000	.643	.722	.846	.667	.654	.464
MCW 78							
N	26	15	14	35	38	9	16
A	.000	.000	.036	.000	.000	.000	.000
B	.019	.000	.321	.257	.118	.167	.156
C	.115	.833	.429	.700	.776	.222	.594
D	.808	.167	.214	.029	.105	.222	.219
E	.019	.000	.000	.000	.000	.000	.000
F	.038	.000	.000	.014	.000	.389	.031
MCW 222							
N	16	13	11	13	12	12	16
A	.000	.000	.000	.192	.167	.083	.031
B	1.000	.615	.455	.577	.292	.792	.500
C	.000	.154	.273	.231	.458	.042	.375
D	.000	.231	.273	.000	.083	.083	.094

Allele frequencies from additional microsatellite markers for group

Locus	Population					
	KK	**NH**	**NN**	**LV**	**OV**	**AU**
adl 104						
N	17	13	14	34	36	18
18	.059	.000	.000	.000	.000	.000
B	.000	.154	.000	.044	.069	.000
C	.000	.000	.250	.441	.167	.194
D	.000	.308	.321	.250	.111	.111
E	.000	.154	.107	.221	.319	.278
F	.647	.346	.286	.044	.292	.222
G	.235	.038	.036	.000	.042	.000
H	.059	.000	.000	.000	.000	.083
I	.000	.000	.000	.000	.000	.000
J	.000	.000	.000	.000	.000	.111
Lei 194						
N	3	22	9	23	19	16
A	.000	.000	.000	.000	.000	.125
B	.000	.000	.000	.000	.000	.313
C	.000	.000	.278	.000	.316	.438
D	.000	.068	.000	.000	.000	.063
E	.000	.000	.056	.413	.237	.000
F	1.000	.409	.278	.587	.211	.063
G	.000	.045	.167	.000	.000	.000
H	.000	.045	.000	.000	.000	.000
I	.000	.432	.222	.000	.237	.000
MCW 34						
N	22	9	19	18	8	20
A	.250	.222	.079	.167	.313	.700
B	.455	.000	.263	.000	.000	.000
C	.227	.000	.000	.000	.000	.000
D	.000	.111	.000	.000	.125	.025
E	.000	.000	.237	.833	.500	.000
F	.023	.056	.000	.000	.063	.100
G	.000	.556	.395	.000	.000	.000
H	.000	.056	.000	.000	.000	.050
I	.045	.000	.026	.000	.000	.125
MCW 37						
N	36	33	31	39	39	20
A	.000	.061	.000	.000	.013	.000
B	.028	.000	.016	.000	.000	.000
C	.056	.076	.339	.000	.423	.450
D	.611	.818	.306	.782	.295	.500
E	.306	.045	.274	.205	.205	.050
F	.000	.000	.032	.013	.000	.000
G	.000	.000	.032	.000	.051	.000
H	.000	.000	.000	.000	.013	.000

Allele frequencies in 6 populations

Locus	Population					
	KK	**NH**	**NN**	**LV**	**OV**	**AU**
MCW 78						
N	26	15	14	35	38	18
A	.000	.000	.036	.000	.000	.000
B	.019	.000	.321	.257	.118	.000
C	.115	.833	.429	.700	.776	.833
D	.808	.167	.214	.029	.105	.111
E	.019	.000	.000	.000	.000	.056
F	.038	.000	.000	.014	.000	.000
MCW 81						
N	16	25	14	26	25	21
A	.000	.100	.000	.250	.040	.048
B	.000	.000	.393	.212	.200	.000
C	.000	.740	.393	.538	.620	.286
D	.438	.160	.000	.000	.040	.000
E	.031	.000	.000	.000	.000	.000
F	.031	.000	.000	.000	.000	.000
G	.250	.000	.000	.000	.000	.000
H	.156	.000	.214	.000	.100	.667
I	.094	.000	.000	.000	.000	.000
MCW 284						
N	13	11	11	17	8	10
A	.000	.000	.000	.000	.125	.000
B	.577	.864	.773	.853	.625	.200
C	.000	.000	.000	.000	.000	.100
D	.000	.091	.000	.000	.000	.000
294	.423	.045	.227	.147	.250	.700
MCW 294						
N	25	19	12	17	24	19
A	.000	.000	.000	.000	.021	.000
B	.980	.000	.250	.265	.167	.000
C	.020	.000	.042	.353	.438	.184
D	.000	.000	.000	.000	.000	.000
E	.000	1.000	.708	.382	.375	.816

Addendum A 2

Microsatellite marker	Group I F_{ST}	Group II F_{ST}	Group III F_{ST}
ADL 268	0.172	0.117	0.130
MCW 067	0.152	0.114	0.145
MCW 069	0.165	0.177	0.176
MCW 098	0.193	0.258	0.211
MCW 103	0.284	0.221	0.205
MCW 111	0.128	0.086	0.082
MCW 183	0.205	0.264	0.231
MCW 216	0.146	0.185	0.165
MCW 248	0.229	0.109	0.141
MCW 295	0.187	0.145	0.137
MCW 330	0.133	0.073	0.105
LEI 194	-	0.262	-
MCW 034	-	0.293	-
MCW 037	-	0.144	-
MCW 078	-	0.279	0.238
MCW 081	-	0.235	-
MCW 284	-	0.208	-
MCW 294	-	0.419	-
ADL 278	-	-	0.153
MCW 014	-	-	0.261
MCW 222	-	-	0.150
Mean	**0.179**	**0.195**	**0.195**

CONCLUSION

In this study the genotypic and phenotypic properties of the native fowl populations of the "Fowls for Africa" program were investigated and successfully characterized.

A set of microsatellite markers were tested and found to be highly polymorphic and appropriate for genetic characterization of the native fowl populations. A total of 23 markers were tested and the variation measured in terms of heterozygosity and genetic distance. It was found that a higher number of markers influenced the variation estimations, as well as the polymorphic nature of the markers. Between 11 and 18 markers were included in the analyses for distance and phylogenetic tree construction. Topology of trees remained the same, but significance values for the clusters tended to increase as more markers were included.

Results indicate that the genetic variation in the native fowl populations is relatively high. The Koekoek and Australorp had the lowest variation, which is in agreement with their history as breeds in South Africa. The Naked Neck population showed the highest variation and a close relationship with both the New Hampshire and Lebowa-Venda populations. A relatively high variation was observed for the Ovambo's and they seem to be unrelated to the other native populations such as the Naked Neck and Lebowa-Venda. This three genetically distinct groups identified using microsatellite markers correlated with the phenotypic traits, described in Chapter 4.

Growth and egg production of these populations tend to be poor in comparison to commercial birds. For the phenotypic traits studied among these native populations, they seem to be more suited for egg production than meat.

In conclusion, the genetic variation found in this study indicates that there are differences among the populations that should be preserved. This may be possible through the continuation of the "Fowls for Africa" program. Genetic differences and the relationships can also be applied in combination with phenotypic traits for selection of an improved native bird for household food production in South Africa.

REFERENCES

AINI, I., 1990. Indigenous chicken production in South-East Asia. *World's Poultry Science Journal.* 46: 51-57.

AJUYAH, A.O., 1999. Rural family poultry production in the South Pacific Region. *First INFPD/FAO Electronic Conference on Family Poultry.* 7 December 1998 - March 5, 1999. ttp://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/LPS/ FAMPO/ famp.o/htm.

ALAN, T. & THOMAS, A., 1992. Poverty and development in the 1990's. Ed. by Alan & Thomas. Oxford University Press.

AOAC, 1975. Official methods of analysis. Association of official analytical chemists. Washington, D.C.

ARRANZ, J.J., BAYON, Y. & PRIMITIVO, F.S., 1996a. Comparison of protein markers and microsatellites in differentiation of cattle populations. *Anim. Gen.* 27: 415-419.

ARRANZ, J.J., BAYON, Y. & PRIMITIVO, F.S., 1996b. Genetic variation at five microsatellite loci in four different breeds of cattle. *Journal of Agricultural Science, Cambridge.* 127: 533-538

BAKER, C. & MANWELL, C.M.A., 1980. Chemical classification of cattle. 2 Phylogenetic tree and specific status of the Zebu animal blood groups. *Biochem. Genet.* 11: 151-162.

BANARJEE, A.K. & SHARMA, R.K., 1998. Breeding possibilities in adverse climatic conditions with special reference to Indian conditions. *Proceedings of the 10th European Poultry Conference of the WPSA - Israel Branch.* Jerusalem, Israel. 21 - 26 June, 1998.

BEUZEN, N.D., STEAR, M.J. & CHANG, K.C., 2000. Molecular markers and their use in animal breeding. *The Veterinary Journal*. 160: 42-52

BITGOOD, J.J. & SOMES, R.G., 1990. Linkage relationships and gene mapping. In: Poultry breeding and genetics. Ed. by R.D. Crawford. Elsevier, Amsterdam, The Netherlands.

BOTSTEIN, D., WHITE, R.L., SKOLNICK, M. & DAVIS, R.W., 1980. Construction of a genetic linkage map in man using restriction fragment length polymorphisms. *Am. J. Hum. Genet.* 32: 314-331.

BRUFORD, M.W. & FUNK, S.M., 1999. Microsatellites in population studies. Microsatellites: Their application and analyses workshop: Dept. Genetics, University of Pretoria. 26 July 1999.

BRUFORD, M.W. & WAYNE, R.K., 1993. Microsatellites and their application to population genetic studies. Current opinion in genetics and development. 3: 939-943.

BUCHANAN, F.C., ADAMS, L.J., LITTLEJOHN, R.P., MADDOX, J.F. & CRAWFORD, A.M., 1994. Determination of evolutionary relationships among sheep breeds using microsatellites. *Genomics*. 22: 397-403.

BUMSTEAD, N & PALYGA J.,1992. A preliminary linkage map of the chicken genome. *Genomics*. 13: 690-697.

CATALOGUE OF THE NATIVE POULTRY OF SOUTH-EAST ASIA. October, 1991. FFTC Book Series. No. 43. Ed. Jan Bay-Peterson. Printed: Kuo Thai Color Printing Co. Ltd.

CHAMBERS, J.R., GAVORA, J.S. & FORTINA, A., 1981. Genetic changes in meat-type chickens in the last twenty years. *Can. J. Anim. Sci.* 61: 555-563.

CHENG, H.H., 1994. Microsatellite markers for genetic mapping in the chicken. *Poultry Sci.* 73: 539-546.

CHENG, H.H., 1997. Mapping the chicken genome. *Poultry Sci.* 76: 1101-1107.

CHENG, H.H, BURT, D.W. & DODGSON, J.B., 1998. Recent advances in poultry genome mapping. *Proceedings: Symposium Series 18th World Conference on Animal Production.* Seoul National University, Seoul, Korea. June 28 – 4 July 1998.

CRAWFORD, R.D., 1990. Origin and history of poultry species. Chapter 1. In: Poultry breeding and genetics. Ed. by R.D. Crawford. Elsevier, Amsterdam.

CRAWFORD, R.D. & CHRISTMAN, C., 1992. Heritage hatchery networks in poultry conservation. In: Genetic conservation of domestic livestock. Ed. by L. Alderson & I. Bodó. CAB International, Farnham. 2 : 212-214.

CRITTENDEN, L.B., PROVENCHER, L., SANTANGELO, L.,LEVIN, H.A., BRILES, R.W., BRILES, E. & DODGSON, J.B., 1993. Characterization of a Red Jungle Fowl by White Leghorn backcross reference population for molecular mapping of the chicken genome. *Poultry Sci.* 72: 334-348.

CROOIJMANS, R.P.M.A., 2000. Gene hunting: Molecular analysis of the chicken genome. Doctoral dissertation, Animal Breeding and genetics Group, Department of Animal Sciences, Wageningen University, P.O. Box 338, 6700AH Wageningen, The Netherlands.

CROOIJMANS, R.P.M.A., VAN KAMPEN, A.J.A., VAN DER POEL, J.J. & GROENEN, M.A.M., 1993. Highly polymorphic microsatellite markers in poultry, *Anim. Genet.* 24: 441-443.

CROOIJMANS, R.P.M.A., DIJKHOF, R.J.M., VAN DER POEL, J.J. & GROENEN, M.A.M., 1997. New microsatellite markers in chicken optimized for automated fluorescent genotyping. *Anim. Gen.* 28: 427-437.

CROOIJMANS, R.P.M.A., VAN OERS, P.A.M., STRIJK, J.A., VAN DER POEL, J.J. & GROENEN, M.A.M., 1996a. Preliminary linkage map of the chicken (*Gallus domesticus)* genome based on microsatellite markers: 77 new markers mapped. *Poultry Sci.* 75: 746-752.

CROOIJMANS, R.P.M.A., GROEN, A.B.F., VAN KAMPEN, A.J.A., VAN DER BEEK, S., VAN DER POEL, J.J. & GROENEN, M.A.M., 1996b. Microsatellite polymorphism in commercial broiler and layer lines estimated using pooled blood samples. *Poultry Sci.* 75: 904-909.

CROW, B., 1992. Understanding famine and hunger. In: Poverty and development. Ed. by Allen & Thomas. Oxford University Press.

DEEPAK, G.Y., KUMAR, SANJEEV, SINGH, R.K., BUTCHAIAH, G. & JOHAN, D.C., 1998. DNA polymorphism in various White Leghorn lines by PAPD-PCR.

DEINER, C., 1999. Characteristics of the egg industry. *Poultry Bulletin.* January 1999. Promass (Edms), PO Box 1192, Honeydew 2040.

DODGSON, J.B. & CHENG, H.H., 1999. Poultry genomics: An alien perspective. *Ag. Boitech. Net.* January, 1999. Vol 1. ABN 005.

DODGSON, J.B., CHENG, H.H. & OKIMOTO, R., 1997. DNA marker technology: A revolution in animal genetics. *Poultry Sci.* 76: 1108-1114.

DUNNINGTON, E.A., STALLARD, L.C. & SIEGEL, P.B., 1993. Evaluating linkage between DNA fingerprint bands and quantitative traits in chickens: Interactions. *Poultry Sci.* 72, 6: 1000-1004.

ERLICH, H.A., 1991. PCR Technology: Principles and applications for DNA amplification. W.H. Freeman and Company, New York.

FIELDS, R.L. & SCRIBNER, K.T., 1997. Isolation and characterization of novel water-fowl microsatellite loci: Cross-species comparisons and research applications. *Molecular Ecology.* 6: 199-202.

FILLION, VALÉRIE, 1998. The chicken as a model to study microsomes in birds: Review. *Genet. Sel. Evol.* 209-219 pp.

GANDINI, G.C. & OLDENBROEK, J.K., 1999. Choosing the conservation strategy. In: Genebanks and the conservation of farm animal genetic resources. Ed. J.K. Oldenbroek. DLO Institute for Animal Science and Health, The Netherlands.

GARCÊS, A., CASEY, N.H. & HORST, P., 2001. Productive performance of naked neck (*Na*), frizzle (*F*) and dwarf (*dw*) laying hens under the climatic conditions of the tropical coastal plain of south-east Africa and two nutritional treatments.

GARCIA-CASAS, C., MORENO, A., CAPOTE, J. & DE LA HABA, M.R., 1992. Characterization of the Canary racial goats groups with erythrocyte genetic markers. *Small Ruminant Research.* 7: 361-368.

GILBERT, D.A., PACKER, C., PUSEY, A.E., STEPHENS, J.C. & O'BRIEN, S.J., 1991. Analytical DNA fingerprinting in lions: Parentage, genetic diversity, and kinship. *J. Hered.* 28: 378-386.

GOLDSTEIN, D.B. & POLLOCK, D.D., 1997. Launching microsatellites: A review of mutation process and methods of phylogenetic inference. *Journal of Heredity.* 88: 335-342.

GOLDSTEIN, D.B., LINARES, A.R., CAVALLI-SFORZA, L.L. & FELDMAN, M.W., 1995. An evaluation of genetic distances for use with microsatellite loci. Genetics. 139: 463-471.

GROEN, A.F., CROOIJMANS, R.P.M.A., VAN KAMPEN, A.J., VAN DER BEEK, S., VAN DER POEL, J.J. & GROENEN, M.A.M., 1994. Microsatellite polymorphism in commercial broiler and layer lines. *Proceedings of the 5th World Simp. Gen Appl. Livestock Production.* Guelph. Vol. 21: 94-97.

GROENEN, M.A.M., CROOIJMANS, R.P.M.A., VEENENDAL, A., CHENG, H.H., SIWEK, M. & VAN DER POEL, 1998. A comprehensive microsatellite linkage map of the chicken genome. *Genomics.* 49: 265-274.

GROENEN, M.A.M., CHENG, H., BUMSTEAD, N., BENKEL, B.F., BRILES, W.E., BURKE, T., BURT, D.W., CRTITTENDEN, L.B., DODGSON, J., HILLEL, J., LAMONT, S., PONCE DE LEON, A., SOLLER, M., TAKAHASHI, H. & VIGNAL, A., 2000. A consensus map of the chicken genome. *Genome Research.* 137-147 pp.

GUNARATNE, S.P., 1999. "Feeding and nutrition of scavenging village chickens". *First INFPD/FAO Electronic Conference on Family Poultry.* 7 December 1998 - March 5, 1999. http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/LPS/ FAMPO/famp.o/htm.

HARTL, L.D., 1988. A primer of populates genetics. 2 Ed. Sinauer Associates, Inc. Publishers. Sunderland, Massachusetts.

HERBERGS, J., SIWEK, M., CROOIJMANS, R.P.M.A., VAN DER POEL, J.J. & GROENEN, M.A.M., 1999. Multicolour fluorescent detection and mapping of AFLP markers in chicken (*Gallus domesticus*). *Anim. Gen.* 30: 274-285.

HILLEL, J., PLOTSKY, Y., HABERFELD, A., LAVI, U., CAHANER, A. & JEFFREYS, A.J., 1989. DNA fingerprints of poultry. *Animal Genetics.* 20: 145-155.

HINES, H.C., 1999. Blood groups and biochemical polymorphisms. In: Genetics of cattle. Ed. by Fries & A. Ruvinsky. CABI Publishing.

HOFMEYR, J.H., BESTER, J., FOURIE, H.J., SCHOLTZ, M.M. & REGE, J.E.O., 1998. Animal genetic resources in Africa. *Proceedings of the World Conference on Animal Production.* Seoul National University, Seoul, Korea. 28 June - 4 July, 1998.

HONEYBORNE, N.S. & JOUBERT, J.J., 1998. Characterising six breeds of poultry adapted for small-scale poultry production. Animal Improvement Institute. Poultry Resource Station, Private Bag X2, Irene 0062, South Africa.

HORST, P., 1997. Project coordinator. Compendium of results of the EEC-Research Project, No. TS3-CT92-0091. Final Workshop at M'Bour, Senegal. December 12, 1997.

HORST, P., 1991. Native fowl as a reservoir for genomes and major genes with direct and indirect effects on the adaptability and their potential for tropically orientated breeding plans – A Review, 1991. Animal Research & Dev. Institut für Wissenschaftliche Zusammenarbeit. Federal Republic of Germany.

HRDINKA, C., ZOLLITSCH, W., KNAUS, W. & LETTNER, F., 1996. Effects of dietary fatty acid pattern on melting point and composition of adipose tissues and intra-muscular fat of broiler carcasses. *Poultry Sci.* 75: 208-215.

JOUBERT, J.J., 1996. The story of the indigenous domestic animals in South Africa. Agricultural Research Centre, Private Bag X2, Irene, 0062, South Africa. (Unpublished).

KITALYI, A.J., 1999. Family poultry management systems in Africa. In: "The scope and effect of family poultry research and development". *First INFDP/FAO Electronic Conference on Family Poultry.* 7 December – 5 March, 1999. http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/LPS/FAMPO/famp.o/htm.

KUHNLEIN, U., DAWE, Y., ZADWORNY, D. & GAVORA, J.S., 1989. DNA fingerprinting: A tool for determining genetic distances between strains of poultry. *Theor. Appl. Genet.* 77: 669-672.

LAMONT, S.J., LAKSHMANAN, N., PLOTSKY, Y., KAISER, M.G., KUHN, M., ARTHUR, J.A., BECK, N.J. & O'SULLIVAN, N.P.O., 1996. Genetic markers linked to quantitative traits in poultry. *Animal Genetics.* 27: 1-8.

LEESON, S & SUMMERS, J.D., 1980. Production and carcass characteristics of the broiler chicken. *Poultry Sci.* 59: 768-798.

MacDONALD, K.C. & EDWARDS, D.N., 1993. Chickens in Africa: The importance of Qasr Ibrim. *Antiquity.* 67: 584-590.

MacHUGH, D.E., SHRIVER, M.D., LOFTUS, R.T., CUNNINGHAM, P. & BRADLEY, D.G., 1997. Microsatellite DNA variation and the evolution, domestication and phylogeography of Taurine and Zebu cattle (*Bos taurus* and *Bos indicus*). *Genetics.* 146: 1071-1086.

MASON, I.L. & CRAWFORD, R.D., 1993. *Global status of livestock and poultry species.* In: Managing global livestock genetic resources. NRC. National Academy Press, Washington, D.C.

McQUEEN, H.A., SIRIACO, G. & BIRD, A.P., 1998. Chicken microchromosomes are hyperacetylated, early replicating, and gene rich. *Genome Res.* 8: 621-630.

MENG, A., GONG, G., CHEN, D., ZHANG, H., QI, S., TANG & GAO, Z., 1996. DNA fingerprinting variability within and among parental lines and its correlation with performance of F_1 laying hens. *Theor. Appl. Genet.* 92: 769-776.

MOISEYEVA, J., 1988. Ancient evidence for the origin and distribution of domestic fowl. *Proceedings of the 10th European Poultry Conference, WPSA - Israel Branch.* Jerusalem, Israel. 21 – 26 June, 1998.

MUKHERJEE, T.K., 1990. Breeding and selection programmes in developing countries. In: Poultry breeding & genetics. Ed. by R.D. Crawford, Elsevier, Amsterdam.

NAHM, K.H., 1997. Korean native Ogol fowl. *World's Poult. Sci. Jnl.* 53: 71-77.

NEI, M., 1978. Estimation of average heterozygosity and genetic distance from a small number of individuals. *Genetics.* 89: 583-590.

NEI, M., 1987. Molecular evolutionary genetics. Columbia University Press, USA.

NEI, M & ROYCHOUDHURY, A.K., 1974. Sampling variances of heterozygosity and genetic distance. *Genetics.* 76: 379-390.

NICHOLAS, F.W., 1996. Introduction to veterinary genetics. Oxford University Press.

O'BRIEN, S.J., 1991. Mammalian genome mapping: Lessons and prospects. *Current Opinion in Genetics and Development.* 1: 105-111.

PECH-WAFFENSCHMIDT, V., BOGIN, E., AVIDAR, Y. & HORST, P., 1995. Metabolic and biochemical changes during heat stress in relation to the feathering degree of the domestic hen. *Av. Path.* 24: 33-44.

PÉREZ-LEZAUN, A., CALAFELL, F., MATELL, E., COMAS, D., RUIZ-PACHECO, R. & BERTRANPETIT, J., 1997. Microsatellite variation and the differentiation of modern humans. *Hum. Genet.* 99: 1-7.

PITEL, F., BERGÉ, R., COQUERELLE, G., CROOIJMANS, R.P.M.A., GROENEN, M.A.M., VIGNAL, A. & TIXIER-BOICHARD, M., 2000. Mapping the naked neck (NA) and polydatctyly (PO) mutants of the chicken with microsattelite molecular markers. *Genet. Sel. Evol.* 32: 73-86

PLOTSKY, Y., KAISER, M.G. & LAMONT, S.J., 1995. Genetic characterization of highly inbred chicken lines by two DNA methods: DNA fingerprinting and polymerase chain reaction using arbitrary primers. *Animal Genetics.* 26: 163-170.

PLUG, I., 1996. Domestic animals during the early iron age in southern Africa. In: Aspects of African archaeology. Ed. by G. Pwiti & R. Saper. University of Zimbabwe.

PONSUKSILI, S., WIMMERS, K. & HORST, P., 1996. Genetic variability in chickens using polymorphic microsatellite makers. *Thai. J. Agric. Sci.* 29: 571-580.

PONSUKSILI, S., WIMMERS, K., VALLE-ZARATE, A. & HORST, P., 1994. Evaluation of genetic variation within different chicken lines by DNA fingerprinting. *Proceedings of the 9th European Poultry Conference.* Glasgow. 7 - 12 August, 1994. 1: 367-368.

RAMLAH, A.H., 1996. Performance of village fowl in Malaysia. *World's Poultry Science Journal.* 52: 75-79.

RAMSEY, K., HARRIS, L. & KOTZE, A., 2000. Landrace Breeds: South Africa's indigenous and locally developed farm animals. Ed. Ramsey, Harris & Kotzé. Farm Animal Conservation Trust, Pretoria.

RUYTER-SPIRA, C.P., DE GROOF, A.J.C., VAN DER POEL, J.J., HERBERGS, J., MASABANDA, J., FRIES, R. & GROENEN, M.A.M., 1998. The HMGI-C gene is a likely candidate for the autosomal dwarf locus in the chicken. *Journal of Heredity*. 89(4): 295-300.

SAFALAOH, A.C.L., KADIGI, H.J.S. & PHOYA, R.K., 1996. Growth performance and carcass characteristics of male Black Australorp, Dwarf Malawi local chicken and their crosses from 8 - 20 weeks of age. *Uiswa Res. J. Agric. Sci. & Tech.* 1(1): 61-67.

SAS, 1992. SAS Institute Inc. SAS/STAT users guide. Markted by SAS Institute (Pty) Ltd, 93 Central Street, PO Box 2837, Houghton 2041, RSA.

SCHERF, B.D., 1995. Developing the global inventory for poultry genetic resources. *Proceedings of the Third Global Conference on Conservation of Domestic Animal Genetic Resources*. 1 - 5 August, 1994. Queens University, Canada. Ed. by Crawford, Lister & Buckley. Rare Breeds International, Warickshire, UK.

SCHMID, M., NANDA, I., GUTTENBACH, M., STEINLEIN, C., HOEHN, M., SCHARTL, M., HAAF, T., WEIGEND, S., FRIES, R., BUERSTEDDE, J-M., WIMMERS, K., BURT, D.W., SMITH, J., A'HARA, S., LAW, A., GRIFFIN, D.K., BUMSTEAD, N., KAUFMAN, J., THOMSON, P.A., BURKE, T., GROENEN, M.A.M., CROOIJMANS, R.P.M.A., VIGNAL, A., FILLON, V., MORISSON, M., PITEL, F., TIXIER-BOICHARD, M., LADJALI-MOHAMMEDI, K., HILLEL, J., MÄKI-TANILA, A., CHENG, H.H., DELANY, M.E., BURNSIDE, J. & MIZUNO, S., 2000. First report on chicken genes and chromosomes. *Cytogenetics and cell genetics*. 90(3-4): 169-218.

SETSHWAELO, L.L & ADEBAMBO, O.A., 1992. The status and conservation of animal resources in Africa. In: Genetic conservation of domestic livestock. Ed. by Alderson & Bodó. CAB International, Farnham. 2: 87-102.

SLATKIN, M., 1995. A measure of population subdivision based on microsatellite allele frequencies. *Genetics.* 139: 457-462.

SLOVER, H.T. & LANZA, E., 1979. Quantitative analysis of food fatty acids by capillary gas chromotography. *J. Am. Oil Chem. Soc.* 56: 933.

SMEETS, H.J.M., BRUNNER, H.G., ROPERS, H.H. & WIERING, A.B., 1989. Use of variable simple sequence motifs as genetic markers: Application to study of myotonic dystrophy. *Hum. Genet.* 83: 245-251.

SMITH, J. & BURT, D.W., 1998. Parameters of the chicken genome (*Gallus gallus*). *Animal Genetics.* 29: 290-294.

SMITH, E.J, JONES, C.P., BARTLETT, J. & NESTOR, K.E., 1996. Use of randomly amplified polymorphic DNA markers for the genetic analysis of relatedness and diversity in chickens and turkeys. *Poultry Sci.* 75: 579-584.

SPIKE, C.A., BUMSTEAD, N., CRITTENDEN, L.B. & LAMONT, S.J., 1996. RFPL mapping of expressed sequence tags in the chicken. *Journal of Heredity.* 87: 6-9.

STALLINGS, R.L., FORD, A.F., NELSON, D., TORNEY, D.C., HILDEBRAND, C.E. & MOYZIS, R.K., 1991. Evolution and distribution of $(GT)_n$ repetitive sequences in mammalian genomes. *Genomics.* 10: 807-815.

STEVENS, L., 1986. Gene structure and organization in the domestic fowl (*Gallus domesticus*). *World Poult. Sci. Jrnl.* 42: 232-242.

STRACHAN, T. & READ, A.P., 1996. Human molecular genetics. BIOS Scientific Publishers.

SWOFFORD, D.L., & SELANDER, R.B., 1989. BIOSYS-1, A computer program for the analysis of allelic variation in population genetics and biochemical systematics. Release 1.7 Illinois. Natural History Survey, Champaign IL.

TAKAHASHI, H., NIKASAWA, Y., NAGAMINE, Y., TSUDZUKI, M. & YAMAMOTO, Y., 1998. Genetic relationships among Japanese Native Breeds of chicken based on microsatellite DNA polymorphisms. *J. of Heredity*. 89(6): 543-546.

TAKEZAKI, N. & NEI, M., 1996. Genetic distances and reconstruction of phylogenetic trees from microsatellite DNA. *Genetics*. 144: 389-399.

TAUTZ, D., 1989. Hypervariability of simple sequences as a general source for polymorphic DNA markers. *Nucleic Acids Research*. 17: 16.

TAUTZ, D. & RENZ, M., 1984. Simple sequences are ubiquitous repetitive components of eukaryotic genomes. *Nucleic Acids Research*. 12: 4127-4138.

TAUTZ, D., TRICK, M. & DOVER, G.A., 1986. Cryptic simplicity in DNA is a major source of genetic variation. *Nature*. 322: 652-656.

THE CONCISE OXFORD DICTIONARY, 1990. Oxford University Press.

TUCKER, E.M., CLARKE, S.W., OSTERHOFF, D.R. & GROENEWALD, J., 1983. An investigation of five genetic loci controlling polymorphic variants in the red cells of goats. *Animal Blood Groups and Biochemical Genetics*. 14: 269-277.

TURNER, P.C., McLENNAN, A.G., BATES, A.D. & WHITE, M.R.H., 1998. Instant notes in molecular biology. BIOS Scientific Publishers Limited, Oxford, UK.

VALLEJO, R.L., BACON, L.D., LIU, H.C., WITTER, L., GROENEN, M.A.M., HILLEL, J. & CHENG, H.H., 1998. Genetic mapping of quantitative trait loci affecting susceptibility to Marek's Disease Virus Induced Tumors in F_2 intercross chickens. *Genetics.* 148: 349-360.

VANHALA, T., TUISKULA-HAAVISTO, M., ELO, K., VILKKI, J. & MÄKI-TANILA, A., 1998. Evaluation of genetic variability and genetic distances between eight chicken lines using microsatellite markers. *Poultry Sci.* 77: 783-790.

VAN KAAM, J.B.C.H.M., VAN ARENDONK, J.A.M., GROENEN, M.A.M., BOVENHUIS, H., VEREIJKEN, A.L.J., CROOIJMANS, R.P.M.A., VAN DER POEL, J.J. & VEENENDAAL, A., 1998. Whole genome scan for quantitative trait loci affecting body weight in chickens using a three generation design. *Livestock Prod. Sci.* 54: 133-150.

VAN ZEVEREN, A., PEELMAN, L., VAN DE WEGHE, A. & BOUQUET, Y., 1995. A genetic study of four Belgian pig populations by means of seven microsatellite loci. *J. Animal Breeding & Genetics.* 112: 191-204.

VILJOEN, W.C.J., 1986. Hoenderrasse. *Pluimvee A2/Boerdery in Suid-Afrika.* Department of Agriculture, Pretoria 0002, South Africa.

VOS, P., HOGERS, R., BLEEKER, M., REIJANS, M., VAN DE LEE, T., HORNES, MIRANDA, FRIJTERS, ADRIE, POT, JERINA, PELEMAN, J., KUIPER, M. & ZABEAU, M., 1995. AFLP: A new technique for DNA fingerprinting. *Nucl. Acids Res.* 23(21): 4407-4414.

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

WEBB, E.C. & CASEY, N.H., 1995. Genetic differences in fatty acid composition of subcutaneous adipose tissue in Dorper and SA Mutton Merino wethers at different live weights. *Small Ruminant Res.* 18: 81-88.

WEBB, E.C., CASEY, N.H. & VAN NIEKERK, W.A., 1994. Fatty acids in the subcutaneous adipose tissue of intensively fed SA Mutton Merino and Dorper wethers. *Meat Sci.* 38: 123-131.

WIEGEND, S., 2000. Final report: Development of strategy and application of molecular tools to assess biodiversity in chicken genetic resources (AVIAN DIV). Institute for Animal Science and Animal Behaviour, Federal Agricultural Research Centre, Braunschweig, Germany 31535 Neustadt.

WEIR, B.S., 1996. Genetic Data Analysis II. Methods for discrete population genetic data. Sinsauer Associates, Inc. Publishers.

WILSON, R.T., TRAORE, A., TRAORE, A., KUIT, H.G. & SLINGERLAND, M., 1987. Livestock production in central Mali: Reproduction, growth and mortality of domestic fowl under traditional management. *Trop. Anim. Hlth. Prod.* 19: 229-236,

WRIGHT, S., 1978. Evolution and the Genetics of Populations: Variability within and among natural populations. Volume IV. University of Chicago Press.

ZHOU, H. & LAMONT, S.J., 1999. Genetic characterization of biodiversity in highly inbred chicken lines by microsatellite markers. *Anim. Gen.* 30: 256-264.