Registration of Papers contributed to the
2nd World Congress on Genetics applied to Livestock Production

GENETICAL PERSPECTIVES FOR POULTRY BREEDING ON IMPROVED PRODUCTIVE ABILITY TO TROPICAL CONDITIONS x)

P. HORST

Institute of Animal Production
Technical University Berlin
Lentzeallee 75, 1 Berlin 33
Federal Republic of Germany

1. Identification of breeding situation and selection parameter

The production efficiency of poultry in the tropics is still comparitively low. Apart from the widely practised low standard of management the most important inhibiting factor is still the hot and humid climate. This results in a permanent reduction in metabolic heat production and in a depression of feed energy intake as well as performance.

On the other hand it has been shown that certain breeds or genotypes differ considerably in their capacity to adapt to high temperatures (WILSON, 1948; FOX, 1951; KHEIRELDIN and SHAFFNER, 1957; ROMIJIN and LOKHORST, 1966; CLARK and AMIN, 1965; PETERSEN et al., 1976). Furthermore distinct "between" and "within" population differences in maintaining the level of performance and in survival rates under longterm heat stress have been demonstrated by HORST and PETERSEN, 1975; 1976; PETERSEN and HORST, 1978.

Therefore it is possible to assume that improvements in poultry production in hot regions could result not only from improved management but also from specific breeding work to increase adaptability of hens. Although an importation of high yielding populations has been proved successful little or no attention was payed to specific tropical breeding problems. For this reason it seems to be worthwhile to evaluate the possibilities for maximizing genetic progress for those regions which are exposed to permanent environmental stresses such as heat, and consequently to insufficient supply of nutrients. Specific selection criteria are desirable to improve feed conversion rate and persistancy in performance in both layer and broiler breeds.

Morphological and physiological characteristics can affect individual differences to heat tolerance; they might indirectly restrict the transfer of selection gaines formerly achieved under temperate enviroments. Therefore it is also important to search for those structures which are specifically connected with productive adaptability in hot environments and to elucidate their genetical basis.

This term "productive ability" - first introduced by PIRCHNER, 1968, into animal breeding-refers to the combined capacity of an animal for tolerance to warm environments and for performance ability under temperate conditions. To date there are no direct parameters available for measuring heat tolerance with genetical significance. The concept of the productive performance under specified conditions will serve therefore as the best basis for comparisons and selection measures with economically orientation.

2. Importance of body size for productive adaptability

Since the avian species have no sweat glands in the skin the main dissipation of excess heat is accomplished by respiratory activity. The efficiency of this mechanism depends on the relative humidity. The respiration rate increases steadily with increasing level of heat stress reaching 150 in extreme situations. On the other hand panting is an energy consuming process. Other ways of reducing the heat load fowls are convection from the body surfache, radiation from the skin (i.g. in connection with spreaded wings) and conduction by direct contact to the ground (especially in deep litter systems). Genetical differences in feathering intensity and colour of the skin can affect these processes to a considerable extent.

However, a very important pathway for protection against heat stress is decreased internal heat production by reduced feed intake and adaptation of behaviour.

x) The research project is supported by means of the GERMAN RESEARCH COUNCIL (DFG)

As the "thermodynamic basal heater" cannot drop below a certain minimum, the status of the individual basal metabolism might be a key characteristic for acclimatability. Genetical differences in the rate of protein synthesis and heat output might also affect individual differences in thermoregulation. Because of the heat increment by protein synthesis and protein degradation, acclimatability is affected by the lean body mass of an animal. Body size per se may act much more significantly on adaptation in this pathway than presently recognized (HORST, 1980 a).

Body size also acts as a factor for body surface, by affecting radiation, convection, evaporation and maintenance metabolism. The balance between heat production and heat storage on one hand and heat loss on the other hand is influenced by the surface to body mass ratio.

In view of the different pathways contributing to the acclimatability of an animal it seems appropiate to consider body size as an important trait for further breeding strategies.

In poultry the general significance of body weight has been originally condensed by NORDSKOG and BRIGGS, 1968 to the expression "Body Weight - Egg Production Paradox", differentiating between genetically and environmentally determined components of body weight effects in the form of size and condition. Recent contribution - by HORST and PETERSEN, 1975 - extends this problem to the "Bodysize-Adaptability Phenomenon" in poultry, which emphasises the actual importance of the genetically (and phenotypically) determined body weight of hens to their productive adaptability in hot environments. The body weight related depressive effect of heat produced not only differs between populations but also systematic genotype x environment-interactions in body weight, laying intensity, feed consumption, and egg weight.(HORST and PETERSEN, 1975; PETERSEN et al., 1976; PETERSEN and HORST, 1978). Also parallel tests in tropical and temperate conditions (MUKHERJEE et al., 1980) confirmed the body size-adaptability phenomenon and verified the former laboratory results, i.e. that larger environmental stress reactions are found in genetically larger body sized groups (Fig. 1).

3. Contribution of specific major genes to productive adaptability

By exploring and exploiting the genetical potential, impetus is given to the usage of single genes in addition to quantitative genetical selection procedures.

Besides the still uncertain success - or failures - with biochemical marker genes (SHELDON, 1980; FLOCK and LEITHE, 1981) the approach of single genes control, can, however, in specific cases enhance breeding and selection. This approach may therefore increase the genetic basis of characteristics and create a new quality of quantitative characteristics and component traits. According to MERAT (1980) about 12 loci carry genes influencing biological efficiency. MERAT's earlier approach has been now specified to the test and breeding use of major genes beneficial to the tropics (HORST, 1980 b). This concept enlarges systematically genetical variation, selection response and crossbreeding variability. The general characteristics and importance of major genes in animal breeding are listed in Table 1.

These principles clearly demonstrate that the use of tropical specified major genes will create a kind of "approp ate breeding technology" for improving the genetical potential for tropical environments. In poultry there seem to exist several genes with unique or multiple effects on adaptability to hot environments. The first compilations of its kind is made for such genes in the Table 2. Among them the best known is the gene for dwarfism, which has been already tested and used in broilers and layers (RICARD, 1976; HARTMANN, 1976; HORST and PETERSEN, 1976). During the course of our tropical orientated breeding program, the first step involved the sex-linked dwarf gene (dw).

These experimental results prove not only the relevancy of reduced body size to the tropics but also demonstrated some valuable side effects of the dw-gene, as feed conversion, persistency, liver fatness, immunological ability, mortality rate, mamilla structure of shell (HORST, 1981).

Of general interest for future breeding strategies is the observation over a wide range body weights; there appears a curvilinear relationship between body weight and egg production (Fig. 2).

Fig. 1

REGRESSION OF BREEDING VALUES FOR EGG PRODUCTION ON BV FOR BODY WEIGHT OF MEDIUM HEAVY BROWN LAYERS (MM) TESTED UNDER TEMPERATE AND TROPICAL CONDITIONS (Source: T. K. Mukherjee et al., 1980)

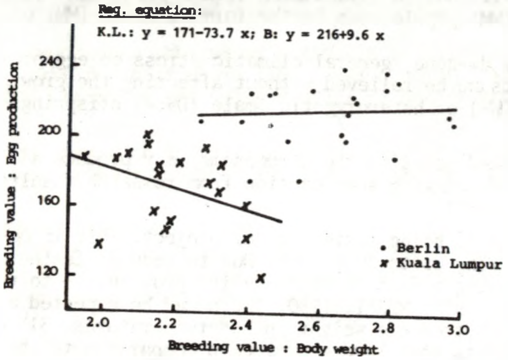
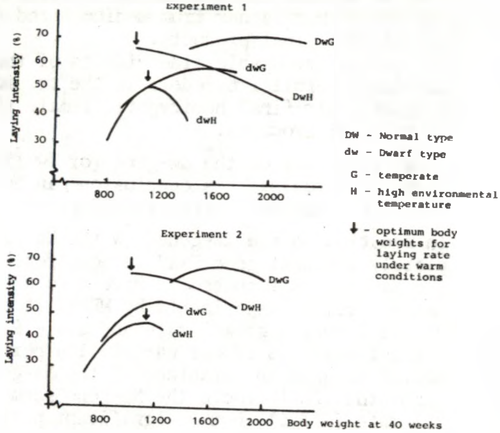


Fig. 2

EFFECT OF ENVIRONMENTAL TEMPERATURES ON THE RELATION BETWEEN BODY WEIGHT AND LAYING INTENSITY WITH NORMAL AND DWARF TYPE OF A LIGHT WEIGHT STRAIN-CROSS (LL) (Horst et al., 1979)



Tab. 1

IMPORTANCE OF MAJOR GENES IN ANIMAL BREEDING

- PRONOUNCED PHENOTYPIC EFFECT ON PHYSIOLOGICAL AND ANATOMICAL CHARACTERS
- DRASTIC MODIFICATION OF CHARACTERS WITHIN ONE GENERATION
- SIMPLE TO MANIPULATE AND TO TRANSMIT INTO EXISTING POPULATIONS
- SIMPLE TO CONSERVE IN SMALLEST POPULATIONS OR AS DEEP FROZEN SEMEN AND/OR EMBRYOS
- CONVENIENT TO INTEGRATE INTO LINE CROSSBREEDING PROGRAMMS BY ESTABLISHING PATERNAL BREEDING LINES WITH DOMINANT AND/OR SEXLINKED MAJOR GENES

Tab. 2

MAJORGENES IN POULTRY WITH DIRECT TROPICAL RELEVANCY

GENE	MODE OF INHERITANCE	DIRECT EFFECTS	INDIRECT EFFECTS
DW DWARF	REZESSIVE, SEXLINKED, MULTIPLE ALLELIC	REDUCTION IN BODY SIZE 30% (-10%)	- REDUCED METABOLISM - IMPROVED FITNESS
Na NAKED NECK	INCOMPL. DOMINANCE	LOSS OF NECK FEATHERS REDUCTION OF SECONDARY FEATHERS (30%)	- IMPROVED ABILITY FOR CONVECTION - SLIGHTLY REDUCED EMBRYONIC LIVABILITY
F FRIZZLE	COMPLETE DOMINANCE	CURLING OF FEATHERS REDUCTION OF SECONDARY FEATHERS	- DECREASED FITNESS UNDER TEMPERATE CONDITIONS - IMPROVED ABILITY FOR CONVECTION
SC SCALELESS	REZESSIVE	ABSENCE OF FEATHER PAPILLAE, NAKED BODY	- IMPROVED ABILITY FOR CONVECTION - REDUCED NATURAL MATINGABILITY
C CHROMOGEN/ MELANIN	DOMINANT	BLACK PIGMENTS IN SKIN AND FEATHERS	- PROTECTION AGAINST RADIATION
O BLUE EGGSHELL	DOMINANT SEXLIMITED	BLUE EGG SHELL	- IMPROVED EGGSHELLSTABILITY

Hence, similar to the "Body Weight - Egg Production Paradox", an optimisation rather then a minimisation is the basis for the "Bodysize-Adaptability-Phenomenon" (HORST, 1981).

This means that the optimum dwarf-layer will not be established from a pure light (LL) population but rather from medium sized (MM) populations in the form of brown (MM) or tinted (ML) final products.
Due to the favourable side effects of the dw-gene, general climatic stress on egg production of broiler breeders in the tropics can be relieved without affecting the growth rate of their final hemizygotic female (DW-) or heterozygotic male (DWdw) offsprings or terminal products.

Finally the use of the dw-gene (or dw linked genes on the chromosome) may produce additional heterosis. This conclusion can be drawn with some caution from research results recently found in Australia (YOO et al., 1980).

In addition to the dw-gene now the Na-gene is being tested in our project. This incompletely dominant gene "Na" reduces feathering up to 30 - 40 %. Due to reduced feathering the Na-gene is supposed to have also a saving effect on high quality protein. As to tentative broiler experiments by MERAT et al. 1974; MERAT, 1980, there can be expected a 9 - 12 % better growth rate and a 6 - 9 % better egg weight in hot temperatures (31° C). A first analysis of our warmstall experiments with layers proved in comparison to the normal na-gene an advantage of the Na-gene of 7.4 % eggmass during the first three layingmonths. Furthermore the Na-gene seems to have a negative effect on embryonic survival rate (-13 %), but a significant positive influence on viability during the laying period.

Despite its effect of body insulation this gene with feather restriction and possible other genes with similar effects (e.g. F) should also show genotype x environment - interactions with better energetic balance in hot environments. Especially the identification of those effects will be of great biological as well as economic importance in developing countries.

Summary

Although great genetical improvements in the tropics are widely achieved by a complete exchange through high yielding strains from temperate countries, additional responses seem possible by inducing special breeding activities on productive adaptability.

A significant genetic contribution consists of the exploitation of the "Body-size x Adaptability-Phemomenon". Further appropriate breeding responses can be expected by the use of the concept of major genes with specific tropical relevance. The selective advantages of those single genes can be seen in

- a simple breeding management
- a rapid change of morphological and physiological structures
- an enlargement of the genetic background with the perspective of an additional selection response.

First experimental results on the significance of body size and on the effect of major genes will be presented.

SOMMAIRE

Bien que grâce à l'introduction intensive de souches issues des régions temperées de grandes améliorations génétiques ont pu être réalisées sous les tropiques, il semble qu' un progrès suplémentaire soit encore possible par l'induction d'activités de sélection spéciales relatives à l'adaptation productive.

Une contribution génétique signifiquante consiste en l'exploitation du phénomén en "taille corporelle-faculté d'aptation". En outre d'autres résultats positifs peuvent être obtenus parlexploitation des gènes dits majeurs de caractère essentiel sous les tropiques. Les avantages particuliers de ce genre de gènes peuvent sont:

- une simple gestion de l'élevage
- un changement rapide des structures physiologiques et morphologiques
- un élargissement du fond génétique permettant une augmentation des possibilités de selection.

Les premiers résultats des expériences effectuées sur l'importance de la taille corporelle et sur les effets des gènes dits majeurs sont présentés.

References

Clark, C. E. and Amin, M.; 1965
The adaptability of chickens to various temperature
Poultry Science, 44, 1003 - 1009

Flock, D. K. and Leithe, H.; 1981
Nutzung von Einzelgenen in der Geflügelzucht
Lohmann-Informationen, Januar 1981

Fox, T. W.; 1951
Studies on heat tolerance in the domestic fowl
Poultry Science, 30, 477 - 483

Hartmann, W.; 1976
Einfluss des Faktors "dw" auf Leistungen von Masstelterntieren und Broilern
Proceedings of the Vth European Conference, Malta

Horst, P. and Petersen, J.; 1975
Untersuchungen zur Auswirkung hoher Umwelttemperaturen auf die Leistungsreaktion von Legehennen mit unterschiedlichen Körpergewichten
Arch. für Geflügekunde, 39, 225 - 231

Horst, P. and Petersen, J.; 1976
Bedeutung des Dwarf-Genes (dw) für die Legehennenzüchtung
Proceedings of the Vth European Poultry Conference, Malta

Horst, P. 1980 a)
Constraints to the genetic improvement of non-ruminants
Proceedings of the 1st Asian-Australian Animal Science-Congress, Kuala Lumpur.
Animal Research and Development, 14, 120 - 135

Horst, P.; 1980 b)
Züchtungsversuche für tropentolerante Legehennen
Deutsche Geflügelwirtschaft und Schweineproduktion, 35, 848 - 854

Horst, P. and Gudßent, W.; 1980
Untersuchungen zur Persistenzbewertung beim Legehuhn
Referat auf der VI. Europäischen Geflügelkonferenz, Hamburg

Horst, P.; 1981
Breeding Perspectives for fowls with improved adaptability to the tropics
SABRAO Conference, Malaysia

Kheireldin, M. A. and Shaffner, C. S.; 1975
Familial differences in resistance to high environmental temperatures in chicks
Poultry Science, 36, 1334

Mérat, P., Bordas, A. and Lefebre, J.; 1974
Effects associés aux gênes dw (Nanisme) et NA ("cou su") chez la poule sur la production d'oeufs et la consommation alimentaire à deux temperatures
Ann. Génét. Sél. Anim., 6, 331 - 343

...

Mérat, P.; 1980
Major genes and biological efficiency in the fowl
World's Poultry Science, 6, 8 - 14

Mukherjee, T. K., Horst, P. Flock, D. K. and Petersen, J.; 1980
Sire-location interactions from progeny test in different countries
Br. Poultry Science, 21, 123 - 129

Nordskog, A.W. and Briggs, D. M.; 1968
The body weight - egg production paradox
Poultry Science, 47, 498 - 504

Petersen, J., Chima, M. M. and Horst, P.; 1976
Bedeutung der Körpertem ratur als Akklimatisationsparameter beim Legehuhn
Z. Tierzüchtg. Züchtungsbiologie, 93, 237 - 251

Petersen, J. and Horst, P.; 1978
Hohe Umwelttemperaturen als auslösender Faktor von Genotyp x Umwelt-Interaktionen beim Legehuhn
Arch. f. Geflügelkunde, 5, 1973 - 1978

Pirchner, F.; 1968
Probleme der Züchtung auf Wärmetoleranz
FAO-Report AN: ABC/ 68 / 6

Ricard, R. H.; 1976
Bases scientifiques de l'utilisation de gêne de nanisme dw dans la production du poulet de chair
Proceedings of the Vth European Poultry Conference, Malta

Romijin, C.; Lokhorst, W.; 1966
Heat regulation and energy metabolism in the domestic fowl
In: Physiology of the fowl

Sheldon, B. L.; 1980
Perspectives for poultry genetics in the age of molecular biology
World's Poultry Science Journal, 36, 143 - 173

Wilson, W. O.; 1948
Some effects of increasing environmental temperatures on pullets
Poultry Science, 27, 813 - 817

Yoo, B. H.; Sheldon , B. L. and Podger, R. N.; 1980
Effects on performance of the DWARF gene in three layer genetic backgrounds
CSIRO Division of Animal Production, Australia