ON DOMINANCE RELATIONS AND THE STRUCTURE OF
ANIMAL SOCIETIES: II.

SOME EFFECTS OF POSSIBLE SOCIAL FACTORS

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In a previous paper (Landau, 1951) it was shown that a society
with a dominance relation would rarely tend to be close to the hierarchy
in structure if dominance is determined solely by the inherent characteristics of the members. Here we consider the effects of other factors,
due to social rank or to the outcome of previous encounters which affected dominance.

The following results are obtained. A uniform bias against reversal of dominance will have no effect on the stationary distribution of the structure of the society. If the probability of dominance is a linear function of the previously established score (number of members dominated), there will be a small tendency for the society to move toward the hierarchy; but this is negligible for large societies. If a member never challenges another whose score exceeds his own by two or more, or if he can never dominate if he should challenge, then the hierarchy is the only stable structure.

From the last result it is concluded that social factors which restrict challenges or the probability of dominance could easily account for societies close to the hierarchy, such as are observed in flocks of domestic hens.

The effectiveness of social bias in establishing hierarchies is much greater in small societies than in large ones.

1. INTRODUCTION. This paper continues the study of the structure of societies with a dominance relation between every pair of members. Familiarity with the previous paper (Landau, 1951, referred to as I) is assumed.

One of the principal conclusions of I was that if dominance is determined solely by the inherent characteristics of the members, then a society with a dominance relation would rarely be close to the hierarchy. By inherent characteristics we mean all those which are not affected by the social status, i.e., the dominance relations, of any of the members or by the results of any previous encounters in which dominance relations were affected. Since, however, societies which are hierarchical in structure, except perhaps for a small number of triangles* \((j > k, k > l, l > j)\) are known to occur, particularly

*A list of symbols is given on page 261.
among domestic hens, it is important to consider whether social factors could produce hierarchies. By social factors we mean all those factors affecting dominance which are not due to inherent characteristics of the members; i.e., social factors are those due to the existing or previous social structure, or dominance relations, or to the outcome of any previous encounters affecting dominance.

This paper considers the mathematical aspects of some possible social factors. Certain assumptions are made as to the operation of factors which depend on the previous history of the society and its members, and conclusions as to the effect on the structure of the society are derived. A detailed discussion of the mechanism of such factors in social, psychological or physiological terms is not attempted. Thus, whether a particular factor could be ascribed to social lag, conditioning or hormone concentration will not be discussed.

The essential difference between the present considerations and those of I is as follows. In I, the picture was that of the \( n \) members of the society coming together and engaging in \( N = n(n - 1)/2 \) contests—one for each pair, or a single round robin—with the result of each contest fixing the direction of dominance for the pair involved. The outcome of each contest was completely independent of that of any other contest, but depended only on inherent characteristics of the members. Our present picture is that the \( N \) dominance relations have been determined by some process, and that thereafter contests (or encounters) occur between some of the pairs. Only one contest is supposed to occur at a time; and we consider various assumptions about the way in which the probabilities of contests or of their outcomes may depend on the previous dominance relations. Each such contest may change the structure of the society, and we wish to be able to draw conclusions about the way in which the structure will vary.* Considerations of this kind were introduced by A. Rapoport (1949, 1950), who calculated some effects of social factors in societies with three members.

A change of structure can occur, as a result of the contests we are considering, only if the dominance relation is reversed, but reversal of a dominance relation does not necessarily result in a different structure. This point will, of course, be considered in detail in

*Other possible treatments might be to consider the development of the structure from an initial state when no dominance relations had yet been established, through the successive stages when \( 1, 2, \ldots, N \) dominance relations have been established. Or again, we might consider what happens when a new member is introduced into a society with an established structure, and thus build up our society by successively adding new members. These approaches will not be treated here.