Creation of a hybrid zone in *Drosophila* with 'allo-sympatric' races

Hybrid zones can provide information and insight into many aspects of speciation such as the origin, establishment and nature of subspecific and specific differences and models of speciation such as reinforcement[1]. Natural hybrid zones of grasshoppers[2,3], butterflies[4], crickets[5], toads[6], birds[7] and mammals[8–10] have provided potential material for hybrid zone research. After an initial phase of reluctance to recognize the importance to hybridization in speciation, zoologists have of late, begun to treat hybrid zones as 'windows on the evolutionary process'[11] and as 'natural laboratories'[12–14]. In this communication we describe the formation of a hybrid zone of *Drosophila* under laboratory conditions and introduce a new concept namely, 'allo-sympatry', related to population distribution and reproductive barriers.

The *nasuta* subgroup of the *immigrans* species group of *Drosophila* is an assemblage of morphologically almost identical forms with different degrees of reproductive isolation[15,16]. Of the 12 recognized members of this subgroup, *D. nasuta nasuta* and *D. n. albomicans*, allopatric siblings, with $2n = 8$ and $2n = 6$ respectively, are cross fertile. Hence they are treated as chromosomal races[17,18]. The hybrids of *D. n. nasuta* and *D. n. albomicans* can be maintained for any number of generations. Interracial hybridization experiments involving these two chromosomal races have been in progress since 1985 in our laboratory and have resulted in the evolution of new karyotypic races. The karyotypic composition of these new races is different from that of the parents, in that the chromosomes of the parents, namely *D. n. nasuta* and *D. n. albomicans* are represented in different combinations. These karyotypically different races have been called cytoraces[19–21]. Within a span of one-and-a-half decades, hybridization as an evolutionary stimulus has influenced the evolution of sixteen cytogenetically different Cytoraces in the laboratory, thus giving rise to a new assemblage called the *nasuta–albomicans* complex within the *nasuta* subgroup, including *D. n. nasuta*, *D. n. albomicans* and the new cytoraces[21].

Hybrid zones in nature occur when genetically distinct groups of individuals meet and mate, resulting in atleast some offspring of mixed ancestry[11,14]. Even though population geneticists and evolutionary biologists have exploited *Drosophila* as a model system for various lines of investigations, they are yet to recognize a hybrid zone of *Drosophila*. The *nasuta–albomicans* complex with the products of interracial hybridization, cytoraces, can be thought of as an 'artificial hybrid zone' in the environs of the laboratory (Figure 1) and a study of the constituent races of this laboratory hybrid zone can be used to enhance our understanding of hybrid zones and race formation in nature.

The cytoraces of this hybrid zone are karyotypically different from one another[21] and have evolved through different lines of hybridizations. The authors are aware of the ancestors as well as their attributes and the time taken in terms of number of generations for the evolution of each of these cytoraces. Therefore, each of these cytoraces has a different, known phylogenetic history. The members of this hybrid zone, that is cytoraces, are maintained in different population cages. Therefore the exchange of genetic material between these phylogenetically and karyotypically different cytoraces is avoided. Thus, each cytorace has been undergoing an independent path of anagenetic changes without the influence of other cytoraces, and hence there is genomic compartmentalization between these cytoraces. The age of these cytoraces is around 200 to 250 generations.

Periodically these cytoraces have been analysed for various parameters for intercytorace and cytorace–parental race comparisons. Such a study has shown a few exciting events in this hybrid zone[22], such as: (i) evolution of a new lineage through centric fission, (ii) emergence of a new neo-Y chromosome, (iii) evolution of heterochromatin-rich and poor strains, (iv) differential selection of parental chromosomes in the hybrids, (v) evolution of homosequential lines, (vi) symptoms of preferential mating, (vii) post-zygotic isolation, (viii) divergence for features such as body size and bristles, and (ix) differences for the parameters of fitness such as fecundity, viability, developmental rate, adaptedness, etc. Thus, the *nasuta–albomicans* laboratory hybrid zone has turned out to be an active site of evolutionary changes and in all probability it is mimicking the events of hybrid zones in nature, but in a laboratory setting it is much easier to undertake rigorous experimental studies.

Based on the pattern of distribution in nature, different species or populations are treated as either allopatric (in geographically different areas), sympatric (in the same geographic locality), or parapatric (contiguous but non-overlapping distribution)[23]. The races of the *nasuta–albomicans* hybrid zone, being in the laboratory are 'sympatric in occurrence' but have similarity to 'allopatric' populations in terms of being reproductively isolated. Therefore, each cytorace is passing through a phase of racial differentiation in 'genetic isolation' through physical, as opposed to behavioural barriers to interbreeding while inhabiting the same area and more importantly common set

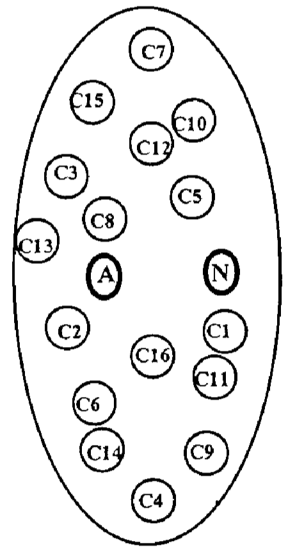

Figure 1. Diagrammatic representation of '*nasuta–albomicans* laboratory hybrid zone'. Each circle represents a population cage with one of the races. C1–C16 = cytoraces – products of interracial hybridization between two parental races, namely *D. n. nasuta* (N) and *D. n. albomicans* (A). In the absence of exchange of flies between cages, these seemingly sympatric races are isolated from one another and hence have an independent path of differentiation, while being under identical environmental conditions. These diversifying races are called allo-sympatric in occurrence. The placement of races in this zone is at random and as such the relative position of these is not an index of genetic nearness or distance between them.

of environmental (i.e. culture) conditions. It is therefore difficult to treat these diversifying races being either as sympatric or allopatric or even parapatric. Hence, a new term namely 'allo-sympatry' is suggested for such an assemblage of populations. We strongly believe that this new term will have implications for sympatric models of speciation which envisage different scenario such as disruptive selection and assortative mating, to avoid exchange of genes between different populations which are apparently sympatric in distribution.

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On the discovery of uranium mineralization in Wahkyn Area, West Khasi Hills district, Meghalaya, India

India's largest sandstone-type uranium deposit at Domiasiat[1,2], containing about 9500 t of oxide at an average grade of 0.1% U_3O_8, was discovered by systematic multidisciplinary investigations in the Upper Cretaceous Mahadek sandstones of the Meghalaya plateau by the Atomic Minerals Division (AMD). On the basis of photogeological studies, a few patches of uraniferous Mahadek sandstone were located near the confluence of the Wahblei and Kynshi rivers[3-5]. Regular radiometric checking in the area, about 12 km WSW of Domiasiat, picked up significant uranium mineralization, assaying more than 11% U_3O_8, in the Lower Mahadek sediments which are exposed on both sides of the Wahblei and Kynshi rivers, henceforth termed as Wahkyn area. This note describes some salient features of the investigated uranium mineralization in this area.

Wahkyn area lies 160 km SW of Shillong and about 5 km NE of Kulang village, West Khasi Hills district. The area is approachable by 140 km long PWD road and 20 km stretch of forest track. The radioactive rock exposures are, however, located in the deep interior of the thick forest, being accessible only through a 5 km long foot track. The terrain is rugged, inhospitable, and the logistics and other infrastructural facilities available are still very poor. The area falls on the southern fringe of the Meghalaya plateau that displays erosional landforms by the Kynshi, Wahblei and Jadukata river system, exposing a thick sequence of Cretaceous–Tertiary sediments overlying the Precambrian basement that comprises of gneisses and migmatites with pegmatitic and granite injections. While the Cretaceous sediments are exposed in the valleys and gorges, the coal- and limestone-bearing Tertiary rocks form the high plateau.

The Cretaceous Mahadek sediments have been divided into Upper and Lower divisions on the basis of their sedimentological and geological characteristics[6]. The 30–60 m thick Lower Mahadek sequence commences with the basal conglomerate unit which is overlain by grey, arkosic sandstone that shows medium- and small-scale cross bedding, ripple cross lamination, scour and fill structure, and fining upward sequence, each unit commencing with pebbly sandstone on an erosional base and ending with fine-grained sandstone, siltstone or shale at the top. Presence of such primary sedimentological features suggest that these sediments were deposited in proximal braided river channels and bars. The channel sediments are in turn covered by medium to coarse felspathic sandstones