

Insecticide Resistance in Mosquitos

Malaria is a leading cause of human illness and mortality worldwide, with 200 million people infected and 600,000 deaths each year. In the 1960s, the incidence of malaria was reduced owing to the use of insecticides that killed mosquitoes in the genus *Anopheles*, which transmit the disease from person to person. But today, mosquitoes are becoming resistant to insecticides—causing a resurgence in malaria. Investigators wondered whether alleles encoding resistance to insecticides have been transferred between closely related species of *Anopheles*.

The analysis of DNA can detect the transfer of resistance alleles between closely related mosquito species. To find out whether such transfers have occurred, DNA was analyzed from two species of mosquitoes that transmit malaria (*Anopheles gambiae* and *A. coluzzii*) and from *A. gambiae* x *A. coluzzii* hybrids.

Table 1 Genotype data in *Anopheles* mosquitos

Observed numbers of mosquitoes by <i>kdr</i> genotype			
	+/+	+/ <i>r</i>	<i>r/r</i>
<i>A. gambiae</i>			
Pre-2006	3	5	2
2006	8	8	7
Post-2006	3	3	57
Hybrids			
2006	10	7	0
<i>A. coluzzii</i>			
Pre-2006	226	0	0
2006	70	7	0
Post-2006	79	127	94

Resistance to DDT and other insecticides in *Anopheles* is affected by a sodium channel gene, *kdr*. The *r* allele of this gene confers resistance, while the wild type (+/+) genotype is not resistant. Researchers sequenced the *kdr* gene from mosquitoes collected in Mali during three time periods: pre-2006 (2002 and 2004), 2006, and post-2006 (2009–2012). *A. gambiae* and *A. coluzzii* were collected during all three time periods, but their

hybrids only occurred in 2006, the first year that insecticide-treated bed nets were used to reduce the spread of malaria. A likely explanation is that the introduction of the treated bed nets may have briefly favored hybrid individuals, which are usually at a selective disadvantage.

Table 2 Allele frequencies for each genotype of *Anopheles* spp

<i>A. gambiae</i>	+/+	+/r	r/r
Pre-2006			
2006			
Post-2006			
<i>A. coluzzii</i>	+/+	+/r	r/r
Pre-2006			
2006			
Post-2006			

1. Complete Table 2 by calculating the *kdr* genotype frequencies in each species for each time period.
2. Describe the change in *kdr* genotype frequencies over time in *A. gambiae*. Propose a hypothesis to account for the observation.
3. Describe the change in *kdr* genotype frequencies over time in *A. coluzzii*. Propose a hypothesis that accounts for the observation.
4. Do the data indicate that hybridization can lead to the transfer of adaptive alleles? Provide reasoning for your answer.
5. Predict how the transfer of the r allele to *A. coluzzii* populations could affect the number of malaria cases in the years immediately following the transfer.