How the physiological changes in a pregnant woman affects the behavioral characteristics of *Anopheles gambiae*.

A review of “Pregnant Women Face Mosquito Menace” by Anita Manning.
Pregnant women attract twice as many mosquitoes than non-pregnant women. This is the topic of interest in “Pregnant Women Face Mosquito Menace” by Anita Manning. This article covers a study performed in Africa by Steve Lindsay and colleagues on how the physiological changes in a pregnant woman affects the behavioral characteristics of one type of mosquito, Anopheles gambiae. This mosquito has been shown to act as a vector for malaria, and could have serious implications if a pregnant woman contracts this disease such as miscarriage, still birth, or low birth weight.

The study involved 36 pregnant women and 36 non-pregnant women, with each woman placed in a bed net alone at night in identical huts and in the morning the number of mosquitoes counted in each hut was used to indicate the woman’s attractiveness for mosquitoes. The study found that in the huts where the pregnant women slept there were twice as many mosquitoes than in the huts with the non-pregnant women. This suggests that there are physiological differences between pregnant women and non-pregnant women that affect the mosquito-host interactions. The mosquitoes must be attracted to certain physiological characteristics that non-pregnant women do not possess, or do not possess at the same extent.

Lindsay suggests that it is the greater amount of exhaled breath that pregnant women produce which allures the mosquitoes. Specifically he says
that it is the greater amount of exhaled carbon dioxide which attracts the mosquitos to the expecting mother. It is also suggested in the article that the mosquitos are drawn to the skin bacteria produced from heat that the pregnant woman produces due to increased metabolic rates from supporting the baby. Although the study was performed on African mosquitos the article suggests that even though American mosquitos have not yet been studied, pregnant women should take care because with the emergence of West Nile virus in North America, they will probably attract more mosquitos than their non-pregnant counterparts and be more vulnerable to contracting the disease which could have detrimental effects on the baby.

The accuracy with which Anita Manning wrote this new article for USA Today is mostly concurrent with recent scientific data on the study of mosquito-host interactions. It has been found that nearly all mosquitos respond to carbon dioxide and the receptors for this compound are on the maxillary palps of the organism (Takken, 1999). Specifically, carbon dioxide is an important compound in the detection of a host for A. gambiae. It appears that the carbon dioxide produced by the host acts as a kairomone, which is a chemical or mixture of chemicals emitted by an organism that induces a response in an individual of another species that is beneficial to the
receiving organism. The mosquito uses the carbon dioxide produced by the host to find the host and feed on it.

The article outlines that it is the overproduction of carbon dioxide by pregnant women in comparison to non-pregnant women, which attracts the mosquitos to the mothers. In studies performed with pregnant women, it has been shown that they do produce more exhaled breath, and this overbreathing in pregnancy causes carbon dioxide to be washed out of the lungs more than in non-pregnancy (Hytten, 1971). Since mosquitos are attracted to carbon dioxide and pregnant women produce more of it, it can be deduced that pregnant women will attract more mosquitos. At least this is the deduction that Steve Lindsay and his colleagues made. It has been shown however that the relationship between the response to carbon dioxide and the concentration of carbon dioxide is nonlinear. Mosquitos often respond to carbon dioxide in a dose-dependant manor within the range of the natural emission rates of the host (Taken, 1999). Instead of assuming that it is the greater amount of carbon dioxide that attracts the mosquitos to the pregnant women, it can be seen that the production levels of the expecting mothers are in the range that the mosquitos receptors consider optimal to induce a response. Amounts of carbon dioxide produced by non-pregnant
women are also in the response inducing range, but it appears that pregnant women produce a more optimal concentration.

There are many other kairomones that the human host produces that the mosquito has been shown to respond to. Such compounds such as acetone, lactic acid, estradiol, lysine and many others act as kairomones between *A. gambiae* and humans. The article also outlines that the heat produced by pregnant women causes more skin bacteria which in turn increases their attraction to mosquitoes. It has been shown that the basal body temperature is raised by 0.3 to 0.6°C during pregnancy (Hytten, 1971), and the article suggests that this heat causes a greater amount of bacteria, which draws the insects to them.

As stated earlier, lactic acid is also a kairomone for mosquito host interactions. Lactic acid is excreted through the skin of humans when they sweat. Since pregnant women are much warmer than non-pregnant women, they will sweat more, therefore excreting more lactic acid. The article neglects to mention that it may be not only be the extra bacteria in the sweat, but also the extra lactic acid that is attracting the mosquitos to the pregnant women. Steve Lindsay in his report suggests that the warmer pregnant women will release substances from the skin and produce a larger host
signature, which allows mosquitoes to detect them (Lindsay, 2000). Anita Manning’s article does not report this possibility.

The physiological characteristics of the pregnant women may not be the only characteristics that cause them to be more attractive to mosquitoes. There are certain behavioral differences between the pregnant and non-pregnant women that will cause a difference in their attraction for the insect. Anita Manning’s article does not mention any of these behavioral changes, however Steve Findlay suggests that since pregnant women in his study left the protection of their bed net at night to urinate twice as many times as the non-pregnant women, this increased their exposure to mosquitoes and therefore the mosquitoes attractiveness to them.

The effect of a mosquito being infected with malaria on its behavioral characteristics was neglected in Steve Lindsay’s study. A recent study in Brazil found that there is a greater susceptibility to *P. falciparum* infection or vulnerability to the *P. falciparum* malaria during pregnancy (Espinosa, 2000). This suggests that mosquitos infected with the malaria vector could be more attracted to pregnant women than the non-infected mosquitos. If this were correct, then one would have to conclude that indeed pregnancy does affect the mosquito-host interactions, but also the *P. falciparum* infection leads to
changes in the insect-host interactions. Lindsay neglected to study whether
or not these mosquitos being attracted to the women were infected with the
malaria even though the study was performed in a malaria-plagued area. Not
only do pregnant women attract more mosquitos, they attract malaria-
infected mosquitos better than non-infected mosquitos. The risk of a
pregnant woman contracting malaria is even greater in light of this new
information. This information is important in taking steps in protecting this
high-risk group from malaria and Lindsay neglected to include this variable
in the study.

In the article, there is the question of whether the warning about
pregnant woman taking caution in North America with the West Nile virus
is a justifiable one based on the study performed in Africa. It is known that
carbon dioxide is a mosquito kairomone and the response to it is in a dose-
dependent manor within the range of natural emission rates of the host. It
appears that in Lindsay’s study, the pregnant women supply the optimal
concentration for A. gambiae to be attracted to. However, we cannot assume
that it would be the same for other species of mosquitos since optimal
concentration may be different for other types of mosquitos. It has also been
seen that lactic acid is a mosquito kairomone, and it seems to hold true for
every type of mosquito, so it seems that pregnant women will attract all
types of mosquitoes in this regard. This in turn gives reason for concern.

As mentioned earlier, a recent study found that not only do the
physiological changes in a pregnant woman attract mosquitoes, but these
physiological changes attract malaria carrying mosquitoes specifically. This is
an important risk factor for women in areas where malaria is prevalent. It is
not yet known, however, whether mosquitoes that are infected with other
diseases, such as the West Nile virus or St. Louis encephalitis, are drawn
specifically to pregnant or non-pregnant women. It therefore cannot be said
that pregnant woman are at greater risk in areas with outbreaks of these
diseases.

“Pregnant Women Face Mosquito Menace” by Anita Manning
presents, overall, an accurate overview of the subject at hand with a few
mistakes. The article outlines Lindsay’s study truthfully and displays his
conclusions almost with the same accuracy. The discrepancy in this article
comes with missing information. The article merely scratches the surface on
the reasons on why *Anopheles Gambiae* are attracted to pregnant women
more than their non-pregnant counterparts. It says that mosquitoes are
attracted to carbon dioxide, implying the more carbon dioxide produced, the
more attractive to mosquitos we will be. This has been shown to be a mistake; the truth lies in there being an optimal concentration that the mosquito associates with a good host. The article also neglects to mention that mosquitos have an attraction to lactic acid, which pregnant women produce more of than non-pregnant women. There is also missing information on the specific attraction of malaria-infected mosquitoes to pregnant women. This is an important part in determining who is at risk to malaria.

The article also implies that the risk of other mosquito carried diseases is large for pregnant women in North America, when in fact it is not known if risks are the same as to those presented with *Anopheles Gambiae* and malaria. The risks may be similar, and because of this, pregnant women should take caution everywhere. This seems to be the take home message of the news report, and although there is no proof of the same situation with North American mosquitos, it is better to be safe than sorry.
References


