THE SELECTION OF GERM IN WHOLE WHEAT BY NEONATAL *PLODIA* LARVAE FOR GROWTH

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Indian meal moths, *Plodia interpunctella* (Hübner), can develop to maturity on a variety of cereal products. Last year, we reported that growth rates are not only dependent upon the nutrient content of the product but also it=s moisture content. In whole kernel wheat, the internal tissues are protected from *Plodia* by a hard pericarp which limits access to internal kernel tissues by neonatal larvae. However, Watts and Dunkel (2003) found that the susceptibility of different wheat varieties to infestation by *Plodia* varied over a broad range. Also, when the pericarp is damaged during harvesting or when cereal grains are crushed or ground during processing, the neonatal larva has full access to the nutrients in the kernel.

When the neonatal *Plodia* larva does gain access to the wheat kernel tissues, e.g. in a damaged kernel, the neonate prefers the germ as its initial nutrient source (Madrid and Sinha, 1982). These authors go on to say that after consuming the germ, the larvae seek out and consume the bran next and finally consume ~ 70% of the endosperm before the end of the last larval stadium. In contrast, Watts and Dunkel reported that *Plodia* larvae feeding on whole wheat prefer the germ, but leave the endosperm exposed at the germ end of the kernel. Thus, the germ in the wheat kernel appears to be a major source of the critical nutrients supporting the growth and development of *Plodia* larvae. However, the nutrient value of the other two kernel tissues, bran and endosperm, is not clear from these studies. Probably neither whole kernel tissue provides much nutrition for the early stage larvae because the bran can=t be chewed and the endosperm contains %-amylase inhibitors which prevents the digestion of the starch.

It was observed in the current study that a newly hatched *Plodia* larva enters the tip of an undamaged soft wheat kernel where the pericarp and other outer kernel layers (collectively called bran) loosely cover the germ. Upon entering the kernel through the folded bran layers the neonatal larva reaches the germ and begins feeding on it exclusively, leaving and re-entering the kernel periodically to deposit frass externally. After ~3 days the larva exits the kernel to molt to the second instar, leaving the head capsule suspended in a light webbing just outside the entry point in the pericarp. It then re-enters the wheat kernel and consumes the remainder of the germ. The larva then exits the first kernel through the original entry point and moves to a second kernel, entering the germ in the same fashion as earlier where it resumes feeding at ~5 days after hatching. It is not until the third instar that larvae consumes bran along with the germ as a nutrient

source and then it is limited to the bran covering the germ area.
There are two scenarios that would direct the neonatal larva to feed on the germ in the wheat kernel. The pericarp could restrict neonate entry into the kernel except in the area already described and the germ is just a tissue convenient to this entry point. Or, the neonate is guided to the germ because it contains a unique array of nutrients that fulfill the immediate nutritional requirements of the first and later instar larva. It is well-established that the pericarp can be a barrier to neonatal larval penetration into the wheat kernel. So the question becomes, is the germ simply located adjacent to a weak point in the pericarp which allows entry of a neonatal larva or is the germ attractive because of special nutritive properties that optimally supports the growth and development of the larva?

This question was resolved by determining larval growth from eggs when fed on the kernel fractions (germ, bran and endosperm) isolated from wheat. Larval growth was fastest on germ, slower on bran and not supported by endosperm. Since none of the kernel fractions performed as well as the standard *Plodia* diet, the kernel fractions were supplemented with 20% glycerol to enhance growth. This supplementation resulted in all three fractions being supportive of larval growth. Growth on bran and germ was now equivalent to growth on *Plodia* diet; significant growth was also observed for the first time on endosperm, but still required additional nutrients to support growth equivalent to *Plodia* diet.

Exploratory experiments indicated that supplementing the kernel fractions with only a simple sugar (sucrose) promoted larval growth in all three kernel fractions, with the increases greatly exceeding the rates without sucrose supplementation. This indicated that both, glycerol and sucrose *via* glycolysis, can provide the energy that is required for larval growth. But, glycerol has the additional property of being a humectant, which increases dietary water content so that water balance is maintained during rapid larval growth which promotes even more rapid growth.

Thus, the authors conclude that neonatal larvae of *Plodia interpunctella* initially seek out the germ to provide nourishment during the early stages of wheat kernel infestation. The neonate gains access to the germ through a loosely closed area in the pericarp covering the germ at the tip of the kernel. The larva feeds on the germ because it is the only tissue in the intact kernel that can provide a high content of vitamins, polyunsaturated fatty acids, sterols and a sizable complement of simple sugars, all of which are essential for the growth and development of the neonate. The bran has a low simple sugar content making this milling fraction nutritionally limited for the larva as well as being difficult to assimilate. The endosperm, which has a large energy supply stored as starch, is nutritionally barren because amylase inhibitors stored with the starch prevent its digestion by the larva. However, both, bran and endosperm, supported larval growth when supplemented with either a simple sugar (sucrose) or glycerol. The conclusion is that neonatal larvae of the Indian meal moth seek the germ because this tissue has the highest simple sugar content which provides the energy needed for growth.