Zaprionus indianus: species identification and taxonomic position.

van der Linde, Kim. Department of Biological Science, Florida State University, Tallahassee, FL 32306-4295, USA; E-mail: kim@kimvdlinde.com

Ten years ago, an enigmatic member of the fruit-fly family Drosophilidae, *Zaprionus indianus* (Figure 1), invaded Brazil (Vilela, 1999). About 5 years later, a second invasion occurred in Florida (van der Linde *et al.*, 2006). This species has been extremely successful in expanding its range and is now found throughout the warmer regions of the Americas (see http://www.kimvdlinde.com/professional/Zaprionus%20indianus.html for the most recent known distribution). The Brazilian population is closely related to that from Principe (Yassin *et al.*, 2008) and has expanded its range across South and Central America up into Mexico and throughout the western USA (Vilela, 1999; Goní *et al.*, 2001; van der Linde *et al.*, 2006; Castrezana, 2007; Rafael, 2007; Lavagnino *et al.*, 2008, unpublished data). The Florida population is closely related to the West African populations of Madeira and Abidjan (Yassin *et al.*, 2008) and has expanded its range across the southern states of the United States toward Texas. This species does not yet have a common English name, but in Brazil, it is called the "African fig fly" or just "fig fly" (mosca (Africana) do figo, Stein *et al.,* 1999; Vilela *et al.,* 2001; Stein *et al.,* 2003; de Almeida Portela da Silva, 2007), a reference to the problems it causes in Brazilian fig culture.

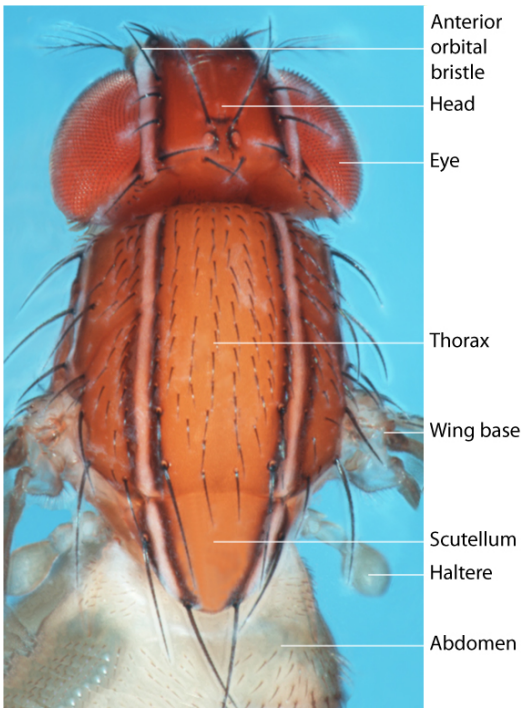

Figure 1. Adult male *Zaprionus indianus* seen from above.

Because of their clear markings, individuals of this species are easily spotted by interested laymen who would like to identify them (see for example Brady, 2007). Species belonging to the genera *Zaprionus* and *Phorticella* are easily distinguished from all other New World drosophilids by their silvery-white stripes, and until now, no other species with similar silvery striping has been reported from the New World (Bächli, 1999-2009), but future invasion of the New World by other *Zaprionus* or *Phorticella* species cannot be ruled out. Establishment of less tenuous means of identifying this species properly and easily is therefore crucial. Unfortunately, currently available published keys for this genus are in French and/or are limited to a subset of species (Chassagnard, 1988; Chassagnard and McEvey, 1992; Chassagnard and Tsacas, 1993; Castrezana, 2007), and some species have not been included in any key (Chassagnard, 1996; Yassin *et al.*, 2008). Furthermore, good knowledge of the morphological terminology used to describe parts of flies is needed for proper use of the existing literature. Consequently, identification beyond a general similarity by comparison of images labeled *Zaprionus indianus* is limited to specialists. To fill this gap, I provide here a list of characteristics that can be observed with a good magnifying glass,

and I provide images of the crucial characteristics (Black-white images in print version, color images in online version).

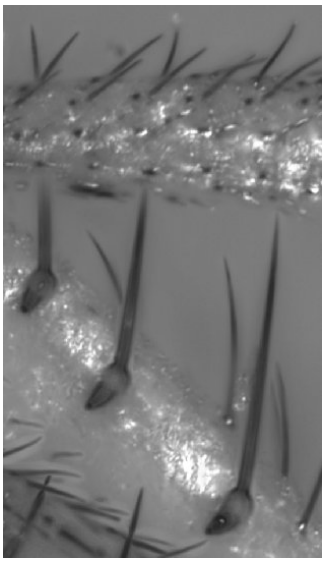

Figure 2. Femur (bottom) of *Z. indianus* with three composite spines characteristic of the *vittiger* species group. In other species, the tibia (top) rests on the spines.

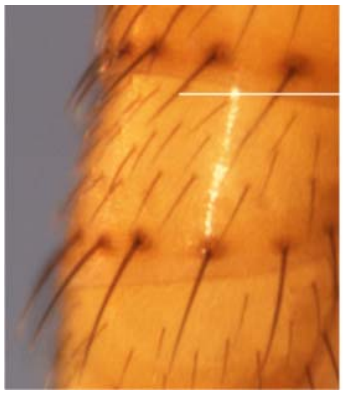

Figure 3. Close-up of the apical setae of *Z. indianus*. Note the black spots they arise from.

Identification of this species is greatly facilitated by the presence of a unique characteristic, namely the composite spines on the femur of the front leg (Figure 2). The presence of these spines places the individual unequivocally in the *vittiger* species subgroup, which includes only 15 species. For a positive identification, all items in the following checklist should be confirmed; the absence of any of them indicates that the specimen is not *Z. indianus*:

1. Basic color of fly (head, thorax, and abdomen) is yellowish (Figures 1, 3).
2. An even number of white stripes bordered by black across the head and thorax (Figure 1).
3. Black stripes everywhere of equal width; stripes do not widen on scutellum (Figure 1).
4. Scutellum without white tip (Figure 1).
5. Presence of composite spines on the femur (the thickest part of the leg, Figure 2) of the foreleg.
6. Composite spines directly on the leg, not on tubercles (*i.e.*, not on small bumps on the surface of the leg; Figure 2).
7. Subapical setae on fourth and fifth tergite (roughly equivalent with the half of the abdomen farthest from the thorax) arise from brownish/blackish spots (Figure 3).

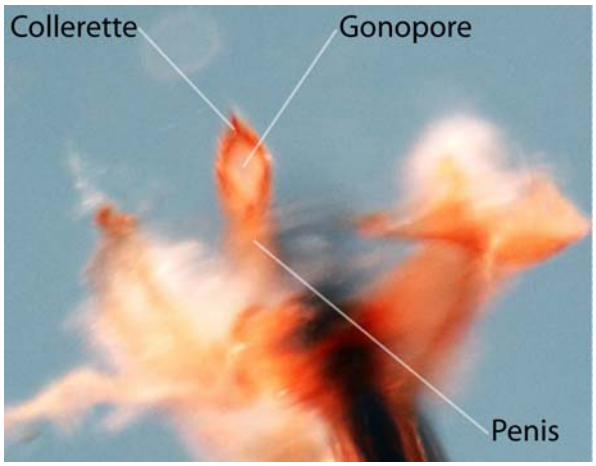

Figure 4. Close-up of the penis of *Zaprionus indianus*. The "collerette", the reddish-brown structure at the tip of the penis surrounding the gonopore, is clearly visible.

The next sections contain the expanded description of the distinguishing characteristics for the various taxonomic levels. *Zaprionus indianus* is assigned to the subgenus *Zaprionus*, species group *armatus,* and species subgroup *vittiger* (Chassagnard

and Tsacas, 1993), and I provide the characteristics for each of these taxonomic levels.

Genus *Zaprionus*: Most species of the genera *Zaprionus* (including *Z. indianus*), *Zaropunis,* and *Phorticella* have distinctive silvery-white stripes on the top of the head and the thorax. Some species in the subgenus *Anaprionus* (genus *Zaprionus*) lack the silvery white stripes and can be confused with other striped drosophilid species such as the species belonging to the *tumiditarsus* and *quadrilineata* species groups (see Yassin, 2007; Yassin *et al.*, 2009). The lobes of the genital arch (epandrium) are truncated in *Phorticella* but finger-like in *Zaprionus,* whereas, the anterior orbital bristle is long in *Zaprionus* but short in *Phorticella* (Figure 1).

Subgenus *Zaprionus*: Within the genus *Zaprionus*, the subgenus *Zaprionus* has an even number of stripes across the thorax (Figure 1), whereas the subgenus *Anaprionus* has an odd number of stripes.

Species group *armatus*: The species of the *armatus* group are characterized by anterior femora that have either one large spine on a prominent tubercle (subgroup *tuberculatus*) or a series of large spines (subgroups *armatus* and *vittiger*, Figure 2), whereas the species of the *inermis* group lack these spines.

Species subgroup *vittiger*: The species of the *vittiger* subgroup, including *Z. indianus*, have 4 to 6 composite spines, each of which has a second short branch at its base (Figure 2). These spines function as a rest for the tibia when the leg is folded. The species of the *armatus* subgroup have simple spines, whereas the species of the *tuberculatus* subgroup have a single long and prominent simple spine on a large tubercle.

Species *indianus*: Within the *vittiger* subgroup, *Z. indianus* is identified by its overall yellowish (not brown) thorax and abdomen and by the narrow (relative to those of the other species) silver bands bordered by black bands across the head, thorax, and scutellum (Figure 1). The black bands do not widen on the scutellum, and the scutellum is without a white tip (Figure 1). Tergites have translucent apical bands, whereas subapical setae on tergite 4 and 5 arise from dark spots (Figure 3). The composite spines are not located on small tubercles as in some other species within the subgroup (Figure 2). The "*collerette*" (Figure 4) (Chassagnard, 1988; Chassagnard and McEvey, 1992), a ruff-like structure surrounding the tip (gonopore) of the penis (distiphallus), is a key characteristic for many species in this group. The *collerette* lacks large lobes, and it is not serrated; it ends in a point that lies on the distiphallus surface (other species have different serration, and the often round ends do not touch the distiphallus surface). Recently, two cryptic species from Central Africa have been described on the basis of genetic differences, and bar-coding is required to distinguish these two species from *Z. indianus* (Yassin *et al.*, 2008).

Acknowledgments: Special thanks go to Stephane Prigent for his insightful comments, Lisa Lyons for use of the microscope, and Anne Thistle for editorial assistance.

References: Bächli, G., 1999-2009. TaxoDros: The Database on Taxonomy of Drosophilidae, from http://taxodros.unizh.ch/; Brady, K., 2007. Grandmother, teen capture surprising fly. In The Norman Transcript/ The Express-Star, from http://www. chickashanews.com/features/ local_story_299130541.html; Castrezana, S., 2007, Dros. Inf. Serv. 90: 34-36; Chassagnard, M.T., 1988, Nat. Can. 115: 305–322; Chassagnard, M.T., 1996, Ann. Soc. Entomol. Fr. 32: 59-65; Chassagnard, M.T., and S.F. McEvey 1992, Ann. Soc. Entomol. Fr. 28: 317-335; Chassagnard, M.T., and L. Tsacas 1993, Ann. Soc. Entomol. Fr. 29: 173–194; de Almeida Portela da Silva, A.P., 2007, Infectividade de *Metarhizium anisopliae* à *Zaprionus indianus* (mosca-do-figo) sob condições

de laboratório. M.Sc. thesis, Universidade Federal de Pernambuco; Goní, B., P. Fresia, M. Calvino, M.J. Ferreiro, V.L.S. Valente, and L. Basso da Silva 2001, Dros. Inf. Serv. 84: 61–65; Lavagnino, N.J., V.P. Carreira, J. Mensch, E. Hasson, and J.J. Fanara 2008, Rev. Soc. Entomol. Argent. 67: 189-192; Rafael, V., 2007, Revista ecuatoriana de Medicina y Ciencias Biologicas 28: 30-43; Stein, C.P., É.P. Teixeira, and J.P.S. Novo 1999, Mosca do figo---*Zaprionus indianus* (in Portuguese), 2005, from http://sites.mpc.com.br/jpsnovo/artigos/zaprionus/index.htm; Stein, C.P., É.P. Teixeira, and J.P.S. Novo 2003, Entomotropica 18: 219–221; van der Linde, K., G.J. Steck, K. Hibbard, J.S. Birdsley, L.M. Alonso, and D. Houle 2006, Fla. Entomol. 89: 402–404; Vilela, C.R., 1999, Dros. Inf. Serv. 82: 37–39; Vilela, C.R., E.P. Teixeira, and C.P. Stein 2001, Mosca-africana-do-figo, *Zaprionus indianus* (Diptera: Drosophilidae) (in Portuguese). Histórico e Impacto das Pragas Introduzidas no Brasil, E. F. Vilela, R. A. Zucchi and F. Cantor. Ribeirão Preto SP, Holos**:** 48–52; Yassin, A., 2007, Dros. Inf. Serv. 90: 20–22; Yassin, A., P. Capy, L. Madi-Ravazzi, D. Ogereau, and J.R. David 2008, Mol. Ecol. Res. 8: 491-501; Yassin, A., J.-L. da Lage, J.R. David, M. Kondo, L. Madi-Ravazzi, S.R. Prigent, and M.J. Toda 2009, Mol. Phylogenet. Evol., online early at http://dx.doi.org/10.1016/j.ympev.2009.09.013.

Genes and the external environmental stimulus.

Gupta, Anand P. Johnson C. Smith University, Department of Science and Mathematics, 100 Beatties Ford Road, Charlotte, NC 28216; E-mail: agupta@jcsu.edu

The effect of external environmental stimulus on genes (the gene expression) is a well documented phenomenon in almost all fields of science that takes account of from microbes to humans. *Drosophila* has been proven to be a *very* powerful tool in such studies since it is very easy to research the genetic and environmental experiments. This is due to its small genome size, easy to work with, does not cause any disease, an adequate sample size for statistical analysis, conclusions drawn through graphical representations, and economical, in addition to several other advantages.

The objectivity of this work is to: 1). study the effect of external environmental stimulus on gene expression in strains of *Drosophila psedoobscura*, High Forest Range, Colorado. 2). compare its graphic results with the other two geographically apart populations collected from Strawberry Canyon and Santa Cruz Island (both in California). 3). implicate the importance of the graphically comparative results (statistical analysis for significant differences not considered here) from an individual human intellectuality view-point in an academic institution.

Experimental Procedure

Eight iso-chromosomal strains for the second chromosome of *D. pseudoobscura* from High Forest Range, 6000 feet above sea level, Colorado, were utilized for the experiment (Gupta, 1978). These strains were maintained in half-pint milk bottles using Carpenters medium. Heterozygous (F_1's) between lines were made by mating pairs of iso-chromosomal lines at random (1 × 2; 3 × 4; 5 × 6; 7 × 8). This was done so as to reconstitute the variety of genotypes present in nature (the results for heterozygote are not discussed here). The phenotypic trait considered for this experiment was the *absolute viability* percent in parents (as defined by Gupta, 1978, 2009a) to provide the experimental