Traditional Knowledge and Rationale for Weaver Ant Husbandry in the Mekong Delta of Vietnam

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ABSTRACT The weaver ant, Oecophylla smaragdina Fabricius (Hymenoptera: Formicidae), has long been known as perhaps the first example of human manipulation of a natural predator population to enhance the natural biological control of insect pests. The practice of ant husbandry in Vietnamese citrus orchards and the knowledge associated with the use of weaver ants in the Mekong delta are described. In contrast to other regions of Asia, where weaver ants are noted for their role in the protection of citrus from insect damage, citrus farmers in the Mekong delta explain the benefits of ant husbandry in terms of an improvement in fruit quality, likened to the influence of fertilizers, that occurs in direct response to excretory products deposited by the weaver ants as they patrol the fruit. A series of tests, carried out in 1993-94, rated the external shine, sweetness, juiciness, and overall appeal, as characteristics of fruit quality, for paired comparisons of sweet orange, mandarin, and pummelo fruit that had been grown in the presence of weaver ants or from which ants had been excluded. The tests indicate a strong influence of the presence of the weaver ant on external shine, juiciness, and overall appeal for each of the citrus fruits, but particularly for mandarin. The significance of these results and ant husbandry practices in the Mekong delta are discussed in relation to the development of citrus production in Vietnam.

Introduction

Traditional farming systems are recognized as valuable sources for agricultural research and development (Altieri, 1990). Even mainstream development agencies such as the World Bank are now acknowledging the importance of incorporating indigenous knowledge in development projects (Warren, 1991). In the Mekong delta of Vietnam, weaver ant husbandry in citrus orchards is a common and ancient practice, and is associated with an impressive body of local knowledge that has not apparently been studied by scientists.

Citrus is a major agricultural product of the Mekong delta, and appears to be growing in importance, as evidenced by the conversion of numerous rice fields into citrus orchards (M. Barzman, unpublished observation). The main *Citrus* species grown in the delta are sweet orange (*Citrus sinensis* Osbeck), mandarin (*C. reticulata* Blanco), pummelo (*C. grandis* Osbeck), and lime (*C. aurantifolia* Swingle). Typically, citrus orchards are small (0.44 ha) family-owned holdings, grown on small raised beds interspersed with a few non-citrus trees. Most citrus producers encourage the presence of a tree-dwelling ant in their orchards in a manner that may be considered husbandry. This ant owes its name "weaver ant" to its nests, which are made up of living leaves woven together. In most regions where it is found, the weaver ant is known as an important predator of plant feeding insect pests. To the inhabitants of the Mekong delta, however, the benefits of weaver ant husbandry are attributed to a direct effect of the ant on fruit quality rather than through predation.

Use of the weaver ant, *Oecophylla smaragdina* Fabricius (Hymenoptera: Formicidae), dating back to the fourth century AD in southern China to protect citrus trees from pests is recognized as the oldest known instance of man-mediated biological control (Huang and Pei, 1987). A number of recent studies have also revealed an important role for the weaver ant in controlling pests. For example, there are reports showing the benefits of *O. smaragdina* against citrus pests in China (Pei *et al.*, 1983) and in the Philippines (Garcia, 1939), against mango and rambuttan pests in Thailand (Chareornsom and Dittaporn, 1990), against cashew, mango, and cocoa pests in Malaysia (Khoo *et al.*, 1991), and against oil palm and coconut pests in Indonesia (Kalshoven, 1981), and of a related African species, *O. longinoda* Latr. against cocoa pests in Ghana (Leston, 1973).

In this context, we designed a study with an initial focus on *Oecophylla*'s pest control potential in Mekong delta citrus orchards. Preliminary data obtained from monitoring the effect of the weaver ant on the composition and abundance of insects on citrus in the Mekong delta (Barzman, Mills, and Nguyen, unpublished observations) show that in the presence of the ant, there is a significant reduction in the abundance of several potential pests. In spite of the weaver ant's potential role as a predator, farmer interviews surprisingly revealed that the primary motivation for ant husbandry in the Mekong delta, in contrast to that in China, is not pest management. Rather, the rationale behind weaver ant husbandry is part of an unconventional but consistent local hypothesis that the ants directly improve fruit quality, an effect that can partially replace the use of soil fertilizers.

Consequently, we expanded our studies on the weaver ant in the Mekong delta to examine the local knowledge and practices associated with the ant. More specifically, we conducted three lines of study, which we present in this paper. First, a series of formal farmer interviews undertaken to objectively assess the rationale for ant husbandry in the Mekong delta. Second, informal conversations with farmers formed the basis for a compilation of beliefs and practices associated with ant husbandry in the Mekong delta. Third, an experiment was devised to test the validity of the local hypothesis that the weaver ant directly improves fruit quality.

Methods

Farmer interviews on the role of the weaver ant

In a formal survey, which took place between November, 1992 and June, 1993, 42 citrus farmers from the Mekong delta provinces of Can Tho, Soc Trang, Vinh Long, and Dong Tap were interviewed. Selection of interviewees was based on their location and their willingness to be interviewed. An effort was made to interview farmers from different locations, although most interviews took place in Can Tho province. Interviews were conducted at the home of the farmer and lasted from one to three hours. The interviews involved a period of open-ended discussion, a question-and-answer session following a preestablished questionnaire, and a visit to the orchard allowing cross-checking of the farmer's statements. The data from these interviews were compiled and are presented as the percentage of farmers responding affirmatively to each of the interview questions.

Traditional knowledge of weaver ant husbandry

Between February, 1993 and March, 1995, a set of seven orchards was visited weekly. During these visits, orchard owners were usually consulted, and a personal relationship with these farmers was thus cultivated. Relevant farmer comments and practices concerning ant husbandry were recorded throughout this period. The information from these visits was qualitative and is presented here as unquantified statements.

Experimental tests of the effect of the weaver ant on fruit quality

To test the scientific merit of the local hypothesis that the weaver ant functions as a crop fertilizer to improve the quality of the fruit, experiments were conducted during 1993 and 1994 in four orchards in Can Tho province, two planted with sweet orange (*Citrus sinensis*) only and two planted with both sweet orange and mandarin (*C. reticulata*), and one pummelo (*C. grandis*) orchard in Vinh Long province using one of two protocols:

a. Between-tree comparison.

The effect of the presence of the weaver ant on the tree was tested in a comparative study of control trees bearing ants and experimental trees from which ants were excluded. The quality of sweet orange fruit was tested in four orchards in 1993 and 1994, and the quality of pummelo fruit was tested in a single orchard in 1993. In each experimental orchard, three trees known to have borne large numbers of ants for at least eight months were selected and match-paired with trees from which ants had been excluded for at least eight months by manually removing their nests and by placing a collar of Tanglefoot at the base of the tree. Weekly monitoring and maintenance of the experimental plots over two years ensured that control trees continued to support substantial ant activity, and that ants were effectively excluded from the experimental trees. Trees were matched according to variety, age, proximity, and general appearance.

b. Within-tree comparison.

The effect of direct contact between weaver ants and fruit was tested on mandarin by within-tree comparison of control fruit to which ants had continuous direct surface contact and experimental fruit from which ants had been excluded (1-4 fruits bagged soon after fruit set with 0.8mm green nylon screen). The quality of experimental versus control fruit was compared using three trees from each of two orchards in Can Tho province in 1993 and one of these orchards in 1994.

The methods employed to compare fruit in both between-tree and within-tree experiments were nearly identical. At harvest (September and October for orange and November for mandarin and pummelo), five to seven ripe fruit were collected from each of the three matched trees in each of the orchards used for the between-tree comparisons and from the matched treatments on the three trees in each of the orchards used for the within-tree comparisons. The fruit were matched visually according to size and maturity without detailed objective measurements, and resulted in 15 to 21 pairs of fruit from each orchard in each year. The harvested fruit were marked to indicate whether or not they had been exposed to weaver ants during their development, using a code unknown to the persons rating the fruit.

Rating of the fruit took place at the house of the orchard owner immediately after collection, matching, and marking. Precautions were taken to conduct the rating of the fruit as a blind test. The person who collected, matched, and marked the fruit did not assist in the rating phase of the experiment. Thus, the people rating the fruit, as well as the person directing the test, did not know from which tree or treatment the fruit originated. The fruit were rated by a group of five to six persons, comprising adults from the orchard owner's household joined, and on a few occasions, by up to two adults from the University of Can Tho when there were not enough household members available.

Each person compared three pairs of fruit (n=15 to 18 pairs of fruit per orchard) for their external shine, sweetness, juiciness, and overall appeal by visual inspection and tasting. For each pair of fruit the rating for each category of fruit quality was entered on an answer sheet in one of three ways: a>b, b>a, or a=b. After answer sheets had been collected, the key to the code was recorded.

To test the hypotheses that fruit grown in the presence of ants are shinier, sweeter, juicier, and have improved overall appeal, the nonparametric sign test, a paired comparison test, was applied to ratings for each set of fruit from each orchard (Siegel, 1956). Significant differences in the fruit quality ratings were tested at the 5% level of significance (one-tailed). This test requires ratings of a=b to be excluded from the statistical analysis, but these ratings are taken into account in the interpretation of the results. The probabilities of the eight independent between-tree tests on sweet orange and the three independent within-tree tests on mandarin were then combined in a $(X^2$ analysis to provide a single aggregate test of the significance of the data from each of the two experimental protocols (Winer, 1971: 49).

Results

Farmer interviews on the role of the weaver ant

An overwhelming majority of the farmers interviewed in the formal survey indicated that they considered the weaver ant beneficial in citrus production, attributed the benefit to improved fruit quality rather than pest management, and actually had these ants in their orchards (Table 1). When asked specifically about the pest control value of the weaver ant, a number of interviewed farmers believed that the ant does provide some protection against citrus pests (Table 1) mentioning among others the citrus green stink bug, *Rhynchocoris humeralis* Thunberg (Heteroptera: Pentatomidae) and the brown citrus aphid *Toxoptera citricida* (Kirkaldy) (Homoptera: Aphididae). But the fact that more than half of the farmers use insecticide on mature trees in their orchards (Table 1) further indicates the minimal pest management role ascribed to the ant. All interviewed farmers compared the ant's effect on fruit quality to increased fertilizer use, and the majority considered nitrogen-phosphorus-potassium fertilizer as a possible, albeit less desirable, substitute for the weaver ant (Table 1). The weaver ant alone, on the other hand, was not considered sufficient as a fertilizing agent as borne out by the fact that all farmers in the survey applied some chemical fertilizer (Table 1). Labor necessary to establish ants, maintain ant bridges, and provide food as well as ant aggression, in the form of biting, were not identified as significant problems by most citrus farmers (Table 1).

Traditional knowledge of weaver ant husbandry

The weaver ant is believed to deposit an excretory product directly onto the surface of the developing fruit that brings about improved fruit quality. The excretory product of the ants, sometimes referred to as "ant urine," is said to increase the shine, sweetness, and juiciness of the fruit. These effects on the three characteristics that are crucial to successful marketing of citrus in Vietnam, are said to be most pronounced on mandarin fruit. Indeed, it is believed that marketable mandarin fruit, even with increased fertilizer use, cannot be produced in the absence of the weaver ant.

Table 1. Results of farmer interviews on the role of the weaver ant in citrus production in the Mekong delta, Vietnam, carried out between November, 1992 and June, 1993.

	%	n
Consider weaver ant beneficial	98	42
Believe weaver ant to improve fruit quality	94	42
Weaver ant present in orchard at time of interview	83	39
Believe weaver ant protects against at least one pest	40	42
Use insecticide on mature trees	59	42
Believe effect of weaver ant is analogous to increased fertilizer use	100	39
Believe effect of weaver ant is superior to increased fertilizer use	90	39
Use chemical fertilizer	100	39
Consider labor for ant husbandry to be small or negligible	88	42
Consider ant aggression a small or negligible problem	89	42

Some ant colonies in orchards are merely tolerated, but the majority are actively cared for, thus justifying the use of the term husbandry. Ant husbandry involves avoiding insecticide use, obtaining and establishing ant colonies, placing bridges between trees, providing food for the ants, and protecting established colonies from competitors.

Farmers usually avoid using insecticides in the presence of the weaver ant. However, in case of an insecticide application to the crop, the main nests of an ant colony, which are often located in large non-crop trees within or near the orchard, will function as refugia and prevent total eradication of the ants from the orchard.

In newly-established orchards, two to three years after cuttings have been planted, weaver ants are usually absent, and farmers must facilitate establishment of the ants in their orchard. To this end, they collect one ant nest from a nearby tree, at night when most ants are inside their nest, enclose it in a bag, and place the open bag in a crop tree. Mandarin orchards often lack a permanent colony of ants, so ants are regularly introduced into the orchard at the stage just following fruit set. Shortly before harvest, the ants may be removed from an orchard to avoid ant aggression interfering with the activity of harvesters.

To improve the patrolling of ants over a broader range of trees within the orchard, farmers make artificial aerial ant bridges from one tree to another. These bridges are usually long bamboo canes that must be replaced after one or two years as they break or decay. Another type of bridge is created by encouraging and directing the growth of a forest liana, *Tinospora* sp. (Menispermaceae), known in the Mekong delta as "ant walking string." Once established, this plant requires no further care and these living ant bridges become permanent.

Food is often provided to the ants. This food consists of animal parts, such as from kitchen waste or a dead animal from the orchard. Farmers never feed the ants freshwater eel, which is believed to cause the ants to develop wings and leave the orchard. The food is either placed directly on a branch or on a coconut shell bearing a hole at the bottom to prevent water from collecting in the dish and fouling the food. The food is placed either near an ant nest or sometimes far from it to lure the ants toward a less well patrolled section of an orchard.

Competition between ant species is recognized as important, thus, a small black ant, *Dolichoderus thoracicus* (Formicidae: Dolichodorinae), known to the Vietnamese as the "smelly ant" is considered a pest, not because it does any direct harm to the crop, but because it is believed to exclude the weaver ant from affected orchard trees. To control the smelly ant, dried rolled coconut leaves or cut grasses are made into a ball and placed in the fork of a main branch of orchard trees. The ball of dried leaves is a preferred nesting site for the ant. After a period of time, the ant traps harboring smelly ant nests are collected and burned. Manual removal or spot spraying of smelly ant nests is also used as a method of control. Some farmers report that in a battle between the weaver ant and the smelly ant, the weaver ant will prevail as long as its nest is built higher in the tree than those of the smelly ant. Intraspecific conflicts are also considered undesirable. Sometimes, territories of different weaver ant colonies overlap, resulting in long battles at the outcome of which large segments of the colonies are lost. It is also reported that these battles result in the death of medium-sized tree limbs from the abundant defensive secretions of the ants. Upon witnessing a weaver ant battle, farmers usually attempt to stop it by spraying water on the combatants.

Increased numbers of scale insects associated with the ants, and the premature death of nest leaves are possible drawbacks in ant husbandry. The main nests of the ant are commonly located in a large non-crop tree within the orchard, but can also be found in the citrus trees. The living nest leaves invariably die prematurely and the nest is then abandoned by the resident ants, which move on to construct another nest elsewhere. Interestingly, the premature death of these leaves used in nest construction was not considered by farmers as a problem. Preliminary data (Barzman, Mills, and Nguyen, unpublished observations) show that there is a definite positive association between the ants and potentially damaging coccid scale insects. The associated coccid scales, however, were not found in such numbers as to require control, neither were they identified by farmers as major pests.

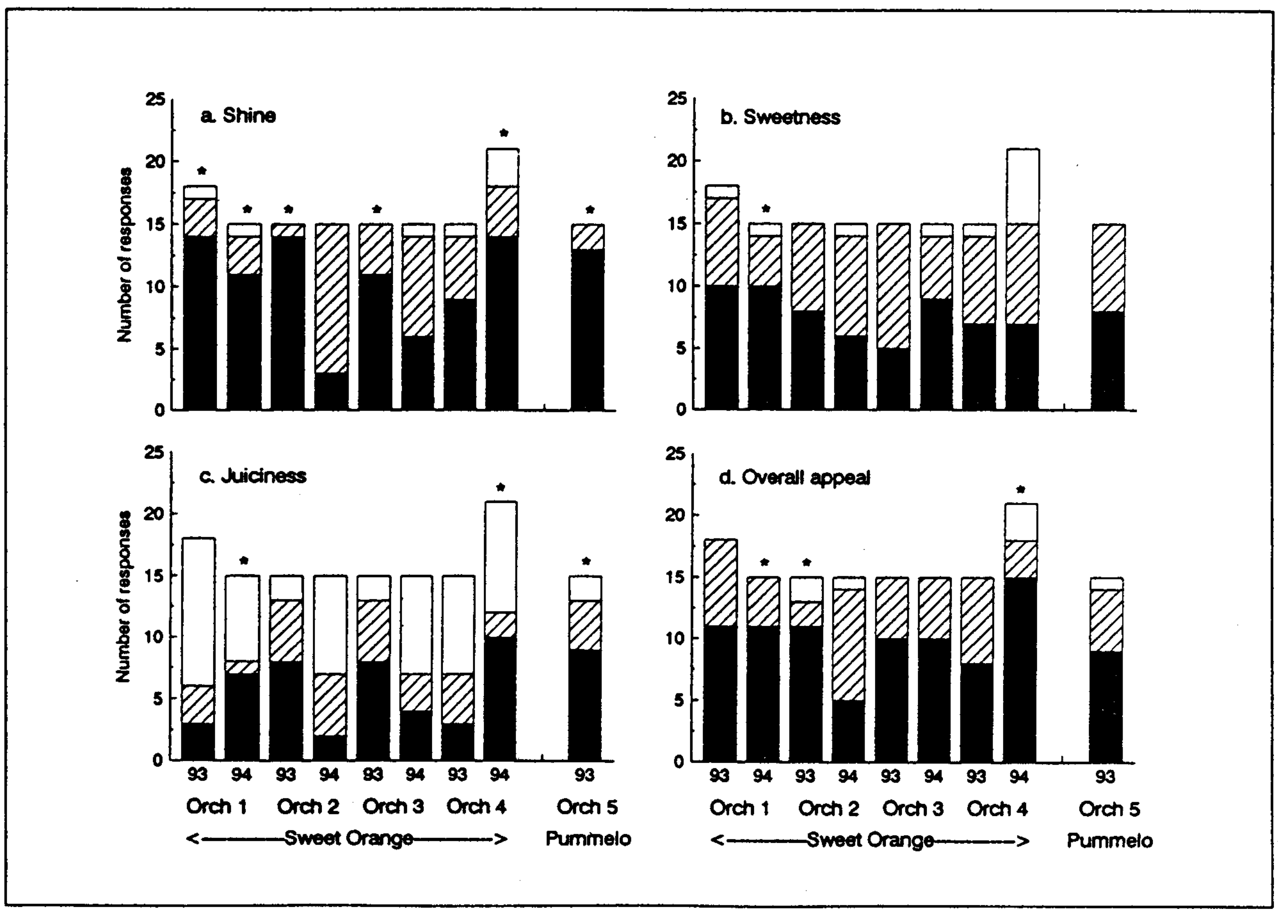
The weaver ant also finds uses outside the orchard. The mixed contents of the weaver ant nest (eggs, larvae, pupae, and adults) are made into a paste used as a sour soup condiment. The large weaver ant larvae are also a favorite freshwater fish bait. These other potential uses of the weaver ant sometimes lead to ant nests being stolen from orchards, which results in an undesirable reduction in ant population abundance, and obviously conflicts with their direct effects on potential pests and fruit quality.

Experimental tests of the effect of the weaver ant on fruit quality

Many of the between-tree tests on fruit quality yielded statistically significant results. Fruit from control trees bearing ants were rated shinier than fruit from experimental trees in six of the eight tests with sweet orange, five providing significant differences (Figure 1a). Fruit from control trees in the single pummelo test were also rated significantly shinier. Sweetness was rated higher in fruit from control trees in half of the tests with sweet orange but only one yielded a significant difference. Fruit from control trees in the single test with pummelo were also rated as sweeter, although this difference was not significant (Figure 1b). Two of the five tests that rated juiciness to be greater for sweet orange fruit from control trees were significant. It should be noted, however, that a=b ratings tended to be numerous in this series of tests (Figure 1c). Pummelo fruit from control trees were rated significantly juicier (Figure 1c). The overall appeal of the fruit from control trees was rated more highly in seven of the eight tests with sweet orange, three of which were significant, and in the single test with pummelo, although the latter was not significant (Figure 1d).

Combining the probabilities of the eight tests with sweet orange fruit in a X^2 analysis, the aggregate effect of the presence of ants in control trees was determined to be significantly positive for external shine (X^2 = 63.7, d.f. = 16, P < 0.001), juiciness (X^2 = 33.8, d.f. =

Figure 1. Between-tree tests of the influence of the presence of weaver ants on fruit quality in sweet orange and pummelo in the Mekong delta in 1993-94. Fruit were rated for (a) external shine, (b) sweetness, (c) juiciness, and (d) overall appeal. ■ represents the number of matched pairs in which fruit grown in the presence of ants rated better for a fruit quality characteristic than fruit from which ants had been excluded, ▨ represents matched pairs in which fruit from which ants had been excluded rated better than fruit grown in presence of ants, and □ represents matched pairs in which both types of fruit were rated equal. * denotes tests for which the rating is significantly better (P < 0.05, one tail test) for fruit in the presence of ants than for fruit from which ants were excluded.



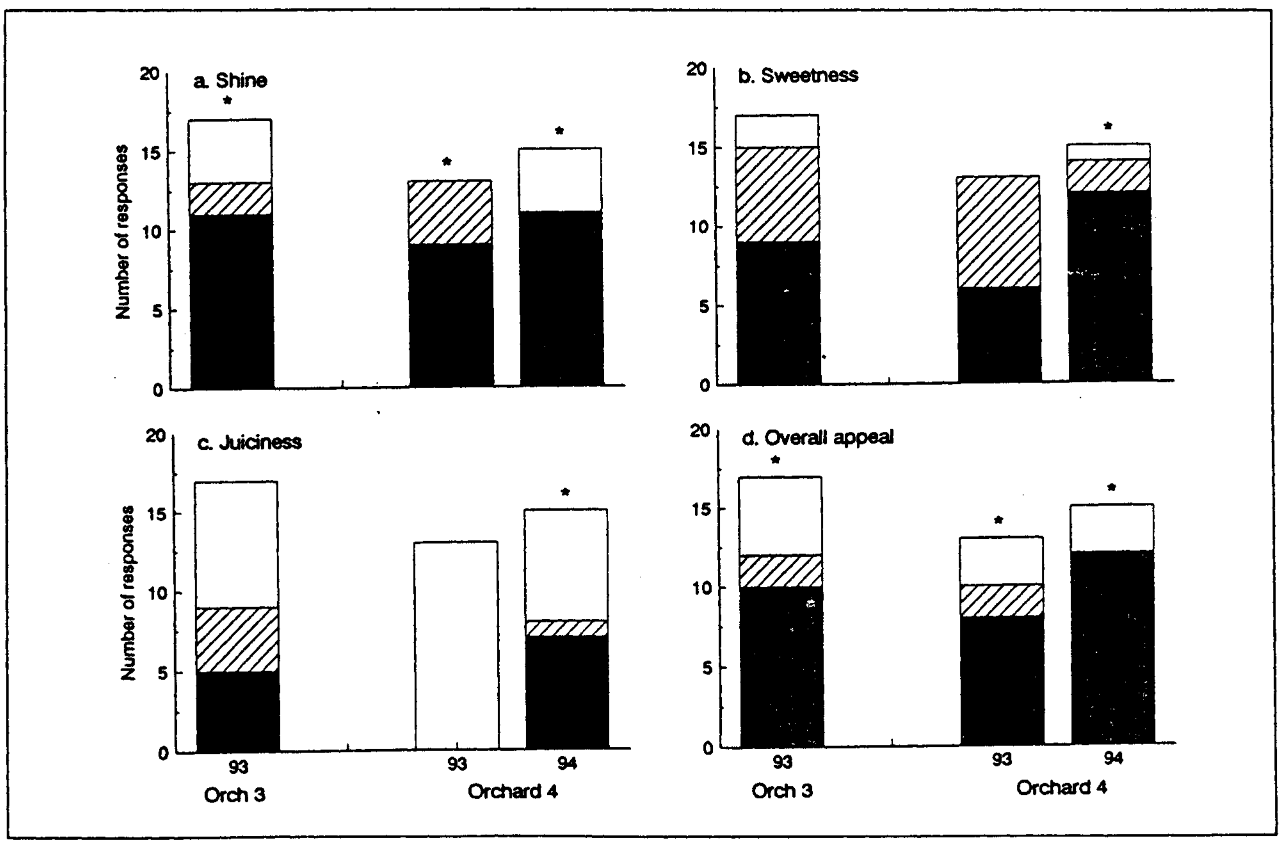
16, P = 0.006) and overall appeal (X^2 = 51.3, d.f. = 16, P < 0.001), but not significant for sweetness (X^2 = 20.5, d.f. = 16, P = 0.20).

For the three independent within-tree tests with bagged and unbagged mandarin, several significant results were also obtained. The external shine of control mandarin fruit was rated significantly higher in all three tests (Figure 2a). Two of the three tests were rated higher with respect to both sweetness and juiciness, but in each case only one test was significant (Figure 2b, 2c). It should be noted, however, that in the case of juiciness there were many a=b ratings (Figure 2c). For all three tests, the overall appeal of the fruit was rated significantly higher (Figure 2d). Combining the probabilities from these three tests into a single aggregate X^2 analysis, external shine (X^2 = 35.4, d.f. = 6, P < 0.001), sweetness (X^2 = 17.3, d.f. = 6, P = 0.008), juiciness (X^2 = 14.2, d.f. = 6, P =0.028) and overall appeal (X^2 = 37.9, d.f. = 6, P < 0.001) were all significantly improved in control fruit exposed to the activities of the weaver ant. It is possible that the differences in fruit quality resulted from a deleterious effect of the mesh bags, used to exclude the ants, on the physiology of fruit development. However, the observed changes in fruit quality are consistent with those obtained from the between-tree comparisons of sweet orange fruit, suggesting that the influence of the ants was the same in both cases and that direct contact between ants and fruit is necessary for this effect to be achieved.

Discussion

Although literature on the weaver ant is abundant, we did not find any reports of weaver ant use for purposes other than biological control. There is little doubt that the weaver ant is an important biological control agent, but in the case of citrus it may also play an additional role in fruit development. It is perhaps possible that the differences in fruit quality that we observed in the presence and absence of ants may be due to the predatory action of the ant. For example, the brown citrus aphid (*Toxoptera citricida*) was less abundant on trees patrolled by ants (Barzman, Mills, and Nguyen, unpublished observations), and as this aphid is a notorious vector of the citrus tristeza virus (Roistacher and Bar-Joseph, 1987), it could have had an indirect affect, via the virus, on the physiology of fruit development. However, the within-tree tests on bagged and unbagged mandarin suggest that the influence of the ants on fruit quality is not systemic, and, despite weekly monitoring of potential pests, no other insects were observed that could be directly responsible for making fruit less shiny, juicy, and sweet. Also, the belief that the ant effect can be substituted by increased use of chemical fertilizer points to a physiological rather than a preda-

Figure 2. Within-tree tests of the influence of weaver ants on fruit quality in mandarin in the Mekong delta in 1993-94. Fruit grading categories, bar fill patterns, and symbols as in Figure 1.



tion phenomenon.

Some elements of internal consistency of the local hypothesis contribute to its credibility. There is considerable uniformity in the description of the local hypothesis among farmers, albeit with some variation on the desirability of ant husbandry, but without any variation on the idea that the ant's excretion induces development of a better fruit. Similarly, there was unanimity with respect to the notion that the ant effect is similar, although not equivalent, to fertilizer use. To farmers, the existence of an ant-tree physiological interaction is so concrete that their own research interest lies in the isolation, identification, synthesis, and marketing of the active ant compound. Indeed, several farmers attempted to shift our research project away from biological control toward natural products chemistry. With this compound made commercially available, farmers envisioned spraying their developing fruit thus making ant husbandry no longer necessary.

The results of the fruit-rating experiments clearly indicate an association between ant presence and increased external shine, juiciness, and overall appeal. There is also a weaker suggestion of an association between ant-presence and sweetness. Since bagging fruit affects many variables, it is possible that the superior fruit quality of the unbagged fruit is directly caused by variables other than the ants' ability to access the fruit surface. However, the fact that the within-tree experiment produced the same results as the between-tree experiment suggests that the actual physical presence of the ant on the fruit is required for the fruit to be affected. If this is true, then the ant effect is not a long-term whole-plant fertilization phenomenon but rather a short-term alteration of the physiology of individual developing fruit. A physiological alteration of plants by ants has previously been documented in the *Piper-Pheidole* mutualistic interaction in which plants receive nutrients from ant wastes and are induced to produce ant food bodies only when ants are present (Letourneau, 1990). It is therefore not inconceivable that the weaver ant, with its complex of exocrine organic compounds (Peerzada *et al.*, 1990; Keegans *et al.*, 1991), some of which are very persistent (Beugnon and Dejean, 1992), may affect citrus fruit in the manner described by the local hypothesis.

Weaver ant husbandry may have originated in the Mekong delta. Several arguments point to a Southeast Asian rather than Chinese geographical origin of this man-ant-tree system. First, *Oecophylla* is recognized as a basically tropical genus (Holldobler and Wilson, 1990). This is evidenced by the difficulty encountered in overwintering the ants in southern China, forcing some farmers to reestablish colonies every spring or to create an artificial winter refugium for the ants (Pu Zhe Long, 1984). Secondly, many of the edible *Citrus* species are believed native to a region encompassing Thailand and neighboring countries (Ratanadaros, 1987), and some consider the mandarin (*Citrus reticulata*) native to southern Vietnam (Rajput and Haribabu, 1985). If it is true, as suggested by Mekong delta farmers, that good mandarin fruit production requires weaver ant presence, a claim also suggested in a quote from fourth century China (Li, 1979 in Huang and Pei, 1987), it seems logical that the ant-tree system would have begun on mandarin in its native area. Lastly, that the local hypothesis is known by everyone in southern Vietnam, even by urban people who may never have set foot in a citrus orchard, reveals the deep-rootedness and antiquity of this tradition.

Weaver ant aggression, not identified as a problem by Mekong delta farmers, has been a major obstacle to its use in other parts of the world. An attempt to use it in Sri Lankan coffee plantations failed due to farm workers being intolerant of ant bites (Leela David, 1961). For the same reason, the weaver ant is sometimes considered a pest in Indonesian tree crops (Kalshoven, 1981). With respect to this problem, the type of land tenure may determine the status of the ant as beneficial or harmful (Dejean, 1992). In a small-sized orchard, labor is typically supplied by family members who in addition to being victims of ant attacks are also, by virtue of owning the crop, the direct recipients of the benefits of ant use. Therefore, in a family-managed holding, the ant is more likely to be considered beneficial. In contrast, labor in a plantation is supplied by wage-earning workers who do not directly share the benefits of ant use and are therefore less likely to tolerate ant aggression.

The recent entrance of Vietnam into the world economy may have a great impact on the country's rural makeup in general, and on citrus production in particular. Despite the high profitability of fruit production in Vietnam (FAO, 1988) and a growing domestic demand for fruit (Barker, 1993), the development of fruit production for export is an enticing prospect to Vietnamese agricultural policy makers who widely believe that export fruit must be produced on plantation-sized holdings (Vo Tong Xuan, 1993). Since most arable land is already in production (FAO, 1988), the creation of citrus plantations implies the displacement of small farmers. In addition, small citrus farmers may not be able to compete against plantations. A change in citrus production from small family-owned holdings to larger scale corporate plantations is likely to result in the loss of traditional practices, such as the use of the weaver ant.

Another consequence of Vietnam's recent entrance into the global economy will be increased pressure to use agrochemicals. An increase in the use of insecticide would probably result in the disappearance of the weaver ant from citrus orchards, as has occurred in China (Pu Zhe Long, 1984). The loss of the weaver ant from citrus orchards would probably be accompanied by an increase in pest pressure due to loss of the predatory effect of the ant, which would make farmers even more dependent on chemical pest control.

One way to help preserve this traditional system is for Western-trained scientists to study the man-ant-citrus system of the Mekong delta and to document its importance to future citrus production. This strategy, viewed by some as a type of exploitation of local knowledge by foreign scientists (Thrupp, 1989), might be effective in Vietnam, where academics and farmers are particularly receptive to scientific validation and where an increased pride in the use of traditional technology could provide an essential step toward sustainable development.

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