ABSTRACT

Histidine is a crucial amino acid for growth in *S. cerevisiae* and plays other important roles for survival in larger eukaryotes. Histidine auxotrophs, organisms that cannot synthesize histidine, often exhibit inhibited growth and development. Research of the model organism, *Saccharomyces cerevisiae*, illuminates eukaryotic uses of amino acids in other eukaryotes. Researchers have also begun to use histidine auxotrophs as a tag in bacterial or expression vectors. However to perform research with histidine auxotrophs, researchers must isolate them from wild type phenotypes. Our study demonstrated one technique to search for these histidine auxotrophs and it may be vital for the years to come in histidine pathway or expression vector research. Our experiment brings to light the simplicity behind much of today’s complex research by taking a basic approach to mutagenesis and selection for mutants.

INTRODUCTION

*Saccharomyces cerevisiae*, common baker’s yeast, has been revered as an excellent model organism for eukaryotes. *S. cerevisiae*, a unicellular, haploid organism is easy to care for and has a rapid generational turnover rate. Research with it allows geneticists to discover the necessary functions, such as the use of amino acids, in eukaryotes. Amino acids provide the building blocks for protein synthesis in eukaryotes and are essential for growth and development. Auxotrophs are organisms that have a genetic mutation that does not allow for them to synthesize certain amino acids. A study on tryptophan auxotrophs who were treated with PHS (phytosphingosine), an inhibitor of tryptophan transport, noted limited growth of the auxotrophs compared to wild type *S. cerevisiae* (Skrzypek 1997).

Histidine, like tryptophan, is an amino acid essential for protein synthesis. *S. cerevisiae* auxotrophs that cannot synthesize histidine may absorb it from their environment to sustain their growth, but growth may still be hindered as exemplified by Skryzpek’s study with tryptophan.
auxotrophs (1997). Larger eukaryotes that cannot synthesize histidine, but can still obtain it from their food sources may experience other problems aside from inhibited growth. In humans, histidine is used to synthesize histamine and carnosine with the help of the enzyme histidine carboxylase (Fitzpatrick 1982). Histamine is a crucial protein for the immune system in humans as it may act as a neurotransmitter to signal for an inflammatory response (Owen 1987). Organisms that must rely on the environment for histidine may not only display inhibited growth, but inhibited defense responses as well.

Thus research on histidine auxotrophs at the level of simple model organisms, like *S. cerevisiae*, are relevant to larger organisms as well. However it is difficult to conduct research on such mutant organisms when mutations rarely occur unless mutagenized. Furthermore, mutant populations must be screened for the organisms with the specifically desired mutation of auxotrophy. The latter complication is often completed in an enrichment procedure. With *S. cerevisiae*, this can be done by changing growth media several times to stall the development of the histidine auxotrophs and then selecting for a different media that kills all wild type and non-histidine mutants who are dividing and growing.

Our study mutated *S. cerevisiae* with a known mutagen, methyl methanesulfonate (MMS). Later following an enrichment procedure, we screened for histidine auxotrophs amongst the general mutant population. We predicted a high rate of mutagenesis by MMS and a high efficiency of our enrichment procedure when selecting for histidine auxotrophs. We expected to see a much higher rate of histidine auxotroph frequency after enrichment.
MATERIALS AND METHODS

Growing *S. cerevisiae* with *ino1* Mutation

The instructor grew the screening strain (JV01) of *S. cerevisiae* (wild type with an *ino1* mutation) in YPD overnight. To complete this, a colony of the JVO1 plate was scraped with a sterile applicator stick and resuspended in 3.0 mLs of YPD. The colony grew overnight in an incubator with shaking at 30°C. The following day, we determined cell concentration by measuring the absorbance of a 1:10 dilution (300μL of cell culture + 2.7 mL H2O) of the cell culture at 660nm (A_{660}) with a spectrophotometer. We extrapolated undiluted cell concentration by multiplying the dilute absorbance by 10 and comparing the calculated undiluted cell concentration to a table of cell density where 1.0 mL of cell culture contained 1.1 x 10^7 cells.

Mutagenesis

We split the yeast culture by adding 1mL of the *S. cerevisiae* in YPD to two separate sterile Eppendorf tubes. To the mutant Eppendorf tube, we added 3 μL of methyl methanesulfonate (MMS) and inverted in several times to mix. Both control and mutant cultures were then placed in a test tube rack and incubated for thirty minutes with shaking at 30°C. After incubation, we spun the tubes in a microcentrifuge at max speed for 30 seconds. We then began to wash the cultures of YPD to switch the medium to SD+His to have a more purified controllable medium. To do so, we removed the supernatant, added 1.0 mL of SD+Hisidine medium to each tube, and resuspended the pellet by vortexing it. The residual YPD and MMS were washed away by spinning the tubes at max speed in a microcentrifuge, removing the supernatant, and resuspending the pellet in 1.0 mL of SD+HIS media. We repeated the wash twice to ensure complete removal of MMS and YPD.
We determined the percent survival of the mutagenesis by plating enough of each washed culture to grow 100 and 500 colonies per plate. This required us to complete a serial dilution of the cell culture (Table 1). Plates were incubated at 30°C for three days. We determined percent survival of mutagenesis by dividing the amount of colonies on the mutagenized plate by the amount of colonies on the control plate.

Table 1. Volumes used for % survival plating

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Mutant</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 cells/plate</td>
<td>205 mL of 1: 10^5 dilution</td>
<td>205 mL of 1: 10^5 dilution</td>
</tr>
<tr>
<td>500 cells/plate</td>
<td>102 mL of 1: 10^4 dilution</td>
<td>102 mL of 1: 10^4 dilution</td>
</tr>
</tbody>
</table>

To a sterile test tube designated for the mutant culture we added 4.5 mL of SD+HIS medium and 0.5 mL of the washed mutagenized culture. Conversely, to a sterile test tube designated for the control culture we added 4.95 mL of SD+HIS medium and 0.05 mL of the washed control culture. Both cultures were allowed to recover from mutagenesis by incubating them with shaking at 30°C overnight. We limited further growth of the cultures by keeping them in a refrigerator until one day prior to enrichment. We woke up the cultures by resuspending them via vortex and transferring 1mL of each culture to separate sterile test tubes containing 4.0 mL of SD+HIS media. Both cultures were then incubated at 30°C with shaking overnight until they could be used for enrichment.

**Enrichment of Histidine Auxotrophs**

8 hours prior to enrichment we transferred 1.0 mL of the overnight cultures to separate Eppendorf tubes and spun the tubes at max speed in a microcentrifuge for 15 seconds. We then removed the supernatant and resuspended the pellet in 1.0 mL of SD media. This wash of SD+HIS with SD-His media was repeated twice more. To two sterile test tubes containing 4.5
mLs of SD-His media, we added 0.5 mL of each washed culture to its own tube. We allowed the 
cultures to grow by incubating them at 30°C with shaking for eight hours. Switching the 
medium from SD+His to SD-His allowed the control culture to grow and to halt growth in the 
mutagenized culture.

By creating a 1:6 dilution of each culture (0.5 mL of cell culture + 2.5 mL of SD), we 
determined cell concentration through absorption (A_{660}) with a spectrophotometer. We 
calculated cell concentration through absorption by using a table of cell density where 1.0 mL of 
cell culture contained 1.1 x 10^7 cells.

The remaining cultures were transferred to Oakridge tubes and spun for five minutes in 
the SS34 rotor at 15,000 rpm. After spinning the samples, we removed 4.0 mLs of the 
supernatant, resuspended the pellet by vortexing it, and transferred the concentrated samples to 
separate Eppendorf tubes. We recollected the pellets by spinning them in a microcentrifuge at 
max speed for 15 seconds. We began washing the culture by removing the supernatant, adding 1 
 mL SD-INO to the tubes, vortexing the cultures and repeating microcentrifugation to recollect 
the washed pellet. We repeated the washing process twice more for a total of 3 washes. To two 
separate sterile test tubes, we added 4.0 mLs of SD-INO media and the entirety of the washed 
culture to its respective tube. Both cultures were then incubated overnight at 30°C with shaking. 
We switched the medium from SD-His to SD-INO to kill off cells that were growing. Histidine 
auxotrophs would have stopped growing from the time spent in SD-His and thus would have 
survived the starvation period in SD-INO.

The following day we began screening for histidine auxotrophs. We plated enough of 
each culture to grow 50 and 250 colonies per plate (Table 2) while acknowledging a 99% killing 
rate that occurred during enrichment. We grew the colonies in an incubator for three days at
30°C after which we moved the plates to a refrigerator until replica plating. The growth of the remaining enrichment culture stocks was limited by keeping the cultures in a refrigerator. We calculated the efficiency of enrichment by comparing the amount of living cells per mL after enrichment to the amount of living cells per mL pre-enrichment.

Table 2. Volumes Used for Enrichment

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Mutant</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 cells/plate</td>
<td>65.9 μL of 1:10³ dilution</td>
<td>151 μL of 1:10¹ dilution</td>
</tr>
<tr>
<td>250 cells/plate</td>
<td>328.8 μL of 1:10³ dilution</td>
<td>75.7 μL of full strength</td>
</tr>
</tbody>
</table>

Selection of Histidine Auxotrophs: Replica Plating

We began our selection of histidine auxotrophs by creating YPD and YC-HIS replica plates of the both cultures’ 50 cells/plate plates. We incubated the replica plates for three days at 30°C and then moved them to a refrigerator until we could begin confirmation of our histidine auxotroph findings.

Confirming the Identity of Histidine Auxotrophs

We refined our selection of histidine auxotrophs by selecting colonies from the replica plates that could grow on the YPD medium plates, but not the YC-HIS medium. These colonies were streaked onto new YPD and YC-HIS plates with a wild type sample from the control. We allowed the cultures to grow in an incubator for 2 days at 30°C and photographed our results.

From our findings, we determined the mutation frequency of histidine auxotrophs. We did so by comparing the number of mutants in the control to the mutagenized culture. We also calculated the factor by which enrichment increased mutant frequency by comparing mutant frequency before and after enrichment.
RESULTS

Mutagenesis

Through spectrophotometry, we determined the concentration of both the original mutant and control cultures to be $4.895 \times 10^7$ cells/mL (Table 3). This value allowed for us to calculate the volume used to plate the mutagenesis efficiency plates and thus determine mutagenesis efficiency. The control plate plated with enough culture to grow 500 cells/plate grew more than 500 colonies and thus both the mutant and control plates of 500 cells/plate were disregarded for accuracy reasons. We observed a significant amount of mutagenesis in our plates plated for 150 cells/plate (Table 4).

Table 3. Percent Survival Throughout Experiment

<table>
<thead>
<tr>
<th></th>
<th>Prior to Mutagenesis</th>
<th>After Mutagenesis</th>
<th>Survival (%)</th>
<th>Prior to Enrichment</th>
<th>After Enrichment</th>
<th>Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>$4.895 \times 10^7$*</td>
<td>$7.59 \times 10^6$</td>
<td>-</td>
<td>$7.59 \times 10^6$</td>
<td>$1.48 \times 10^7$</td>
<td>195.13</td>
</tr>
<tr>
<td>Mutant</td>
<td>$4.895 \times 10^7$</td>
<td>$3.30 \times 10^5$</td>
<td>4.67</td>
<td>$3.30 \times 10^5$</td>
<td>$1.92 \times 10^3$</td>
<td>0.58</td>
</tr>
</tbody>
</table>

* Cell concentration determined through spectrophotometry

Table 4. Mutagenesis Efficiency

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Mutant</th>
<th>% Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 cells/plate</td>
<td>150</td>
<td>7</td>
<td>4.67</td>
</tr>
<tr>
<td>500 cells/plate</td>
<td>Lawn growth observed, calculations disregarded</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Enrichment

Spectrophotometry also allowed for us to discover the cell concentration after mutagenesis of the control and mutant cultures (Table 3). The control culture was far more concentrated than the mutagenized culture. We took this into account when plating for efficacy
of enrichment. As expected, we observed a killing rate of about 99% as we saw only 0.58% of the mutants survive (Table 3 and Table 5).

Table 5. Determination of Efficacy of Enrichment

<table>
<thead>
<tr>
<th>Plate</th>
<th>Total Number of Colonies</th>
<th>Volume Plated (mL)</th>
<th>Dilution Factor</th>
<th>Number of Live Cells/ mL</th>
<th>% Survival of Enrichment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutant</td>
<td>29</td>
<td>151.0</td>
<td>$10^1$</td>
<td>$1.92 \times 10^3$</td>
<td>0.58</td>
</tr>
<tr>
<td>Control</td>
<td>976</td>
<td>65.9</td>
<td>$10^3$</td>
<td>$1.48 \times 10^7$</td>
<td>195.13</td>
</tr>
</tbody>
</table>

**Mutagenesis Frequency**

Initially from our replica plates, we observed four possible mutants out of twenty-nine colonies (mutation frequency post-enrichment= 13.8%). However, when we streaked these colonies for a secondary assessment, we observed only one colony that could grow on YPD plates, but not YC-His plates (Figure 1). We concluded our study of *S. cerevisiae* histidine auxotrophs demonstrated a 3.4% mutagenesis frequency. Enrichment greatly increased our finding of His-mutants by a factor of 170 (Table 6). Prior to enrichment we observed 0.02% mutant frequency, however after enrichment; we observed 3.4% mutant frequency (Table 6).
Figure 1. Confirming the identity of histidine auxotrophs

Four suspected mutant colonies and one wild type colonies were tested for their ability to grow on YPD, but not YC-His plates. Three of the four colonies grew on both plates suggesting wild type characteristics, but the one mutant colony (labeled with arrows) could not grow on the YC-His plate.

Table 6. Efficacy of Enrichment

<table>
<thead>
<tr>
<th></th>
<th># Surviving After Enrichment</th>
<th># Surviving Before Enrichment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Cells</td>
<td>His-Mutants</td>
</tr>
<tr>
<td>Control</td>
<td>1.48 x 10^6</td>
<td>0</td>
</tr>
<tr>
<td>Mutant</td>
<td>1.92 x 10^3</td>
<td>66.21</td>
</tr>
</tbody>
</table>

Factor: 7.59 x
DISCUSSION

Our data supported our hypothesis as our forward genetics experiment demonstrated a high rate of mutagenesis of *S. cerevisiae* using MMS. The high rate of mutagenesis increased our odds for selecting histidine auxotrophs. This selection was further refined using a highly efficient enrichment procedure that increased the frequency His-mutants by a factor of 170. In conclusion, our study practices an excellent technique for the mutagenesis and selection of histidine auxotrophs.

There are several caveats to our study that require further analysis. The one of most concern centers around the fact that after enrichment the control culture had a survival rate of 195.13% which implies the population almost doubled during enrichment. This could be explained by human error. It could be possible we plated too much of the control culture than we calculated for or there may have been an error when making the serial dilution. Both errors would reflect in possible growth of populations.

Our experiment still lays the fertile soil for future research in both the direction of histidine auxotrophs and efficacy of enrichment. Our study demonstrated the astounding effects of enrichment as we had a 170 fold increase in mutation frequency in our mutagenized sample. Enrichment clearly allows for the true results of a study to shine through more easily by concentrating the desired mutant within a culture. However, enrichment can also be applied in a variety of techniques and may help uncover rare and subtle genetic characteristics. Gardner *et al.*, using a modified enrichment procedure based on the magnetic and biotin capture of repeating sequences, isolated and identified more than ten tetranucleotide sequences in a social lizard, *Egernia stokesii* (1990). These tetranucleotide sequences can then be used in future research to determine evolutionary links amongst *E. stokesii* and other lizards. Thus further research that
expands enrichment techniques may help solve dilemmas on a grander scale of big biology as it can help refine phylogenetic trees with a subtle genetic touch.

Research of histidine auxotrophs illuminates the prevalence of certain bacterial ailments. Juliao et al. showed histidine is detrimental to bacterial growth and survival of Haemophilus influenza (2007). Otitis media lacking histidine allowed for limited growth and survival of H. influenza while throat media rich with histidine and other nutrients allowed for the auxotroph bacteria to flourish. Additionally, future research of histidine auxotrophs opens the door to tagging expression vectors. Expression vectors create heterologous DNA by inserting specific genes in with a plasmid. Often times, the plasmids are tagged with histidine auxotrophic characteristics when the desired characteristic of the plasmid does not have an obvious or apparent phenotype. Thus by growing the samples on medium lacking histidine, researchers can monitor integration of the plasmids by survival of the heterogenous samples. Samples with greater integration will survive in greater proportions compared to samples with little plasmid integration (Pronk 2002). Our study demonstrated one technique to search for these histidine auxotrophs and it may be vital for the years to come in bacterial or expression vector research. Our experiment brings to light the simplicity behind much of today’s complex research by taking a basic approach to mutagenesis and selection for mutants.

WORKS CITED


Fair Welcome and the Temple of Priapus: Speakers and Readers as Autoeroticists and Voyeurs in *The Romance of the Rose* and Chaucer’s *The Parliament of Fowls*

1: Autoeroticism

Prominent among the themes of the 13th-century poem *The Romance of the Rose* is that of voyeurism. Denied physical possession of the rose, the speaker is nevertheless “very pleased to be able to stay so close to the rose that [he] could have touched it.” (*Romance* 43) The sexual undertones of the rose become more blunt later in the poem: in his second close contact with the rose the speaker describes how much “more beautiful and redder” it is than before (52); by the end of the poem he has “shaken the bud” and “scattered a little seed there […] probing its very depths,” at this point moving beyond voyeurism to euphemized yet obvious sexual contact. (334) The striking sexual overtones, in effect, imbue the *Romance* with an element of pornography.

Given Geoffrey Chaucer’s literary indebtedness to *The Romance of the Rose*, it is unsurprising that he draws on this same voyeuristic theme in his dream poetry. However, his agile imagination interrogates these themes rather than parroting them, taking them in a less idealized direction than does the *Romance*. The temple of Priapus in *The Parliament of Fowls* is dim, close and tawdry, not a shrine of desire, but of desire frustrated. This less rosy vision of sexuality is complicated by the fact that Chaucer’s speaker is also a voyeur, gazing upon the half-naked body of Venus, and that he chooses to share the experience of his spying with the reader. The sharing of voyeuristic experiences in fact underlies much of both poems’ treatments of sexuality; in effect (because the speakers have chosen to share their private glimpses of sex and nudity) they implicate the reader in the experience. That is, such scenes, which could be
handled by allusion, are really for the reader’s benefit rather than the speaker’s. In this light, Chaucer’s decision to make the temple of Priapus so uncomfortable suggests a commentary on the medieval literary practice of what is effectively pornography. His motive, as I will show, is his interest in interpersonal relationships rather than courtly autoeroticism. Chaucer is attempting to move away from the mirror of Narcissus, so to speak, to a more interpersonal kind of narrative, and in so doing uses the concept of voyeurism as a tool to manipulate and instruct the reader.

Such autoeroticism as Chaucer questions is part and parcel of the *Romance of the Rose*. The speaker’s love for the rose comes by way of the mirror of Narcissus; the Greek figure’s mythic self-love is a strange framework for a relationship unless one supposes the speaker’s feelings to be inwardly directed (i.e., self-directed or selfish). Also, the fact that the rose is a rose in the first place is significant, as in the myth of Narcissus the eponymous youth is turned into a flower for his self-obsession—the rose, in this light, can represent the speaker himself. Thereby the rose—and the courtly love the *Romance* purports it to represent—fades into the background, leaving only the speaker and his autoerotic feelings. Furthermore, the figure of Fair Welcome, who in the *Romance*’s allegorical structure represents the maiden whose virginity the rose represents, is depicted as “a handsome and pleasant […] young man,” stripping femininity of any sexual role in relation to the speaker and replacing it with a figure mirroring the speaker himself. (43) The *Romance* can easily be read as a story of self-obsession and lust rather than the instructive allegory in courtly life that it was received as. Even the *Romance*’s second author, Jean de Meun, seems to have taken note of this and found the issue worth exploring, as he concludes the poem with the speaker “[breaking] the bark” and “plucking the rose,” turning the earlier coy voyeurism into what is arguably a rape. (334, 335) Chaucer noticed this as well.
The temple in the garden in Chaucer’s *The Parliament of Fowls* is full of “syghes hote as fyr […] which […] were engendred with desyr,” yet also with “sorwes […] Com of the bitter goddesse Jelousye.” (*Parliament* 103, 104) Chaucer appends to his exposé of the unhappy side of lust a depiction of Priapus as the “sovereyn” of the temple. (104) The god cuts a ridiculous figure, bedecked in flowers and “with his ceptre in honde”. (104) In short, Chaucer chooses as the patriarch of his temple a chagrined, lewd figure whose only apparent recourse in frustration is to masturbate. At the same time, Venus lounges in a secluded, dim corner “naked fro the breste unto the hede.” (104) Her benevolence, however, is arguable: all around the temple walls are hung “bowes y-broke”, deliberately uncomfortable symbols of lost virginity. (104) As in the *Romance*, extreme self-love is juxtaposed with the loss of someone else’s virginity. However, Chaucer takes care to make the temple of Priapus an eerie, disturbing place. His implication is that self-love is associated with rape (for the “bowes y-broke” surely did not enjoy being splintered in two). Given such a claim, one would expect an alternative; Chaucer happily provides one, illustrating it through the parliament of fowls itself.

The parliament’s Nature-driven discussion of love and marriage is a counterpoint to the temple’s description of the wrong kind of “love.” In the fowls’ debates over which tercelet eagle should wed the formel, various methods of arranging relationships are discussed, until Nature at last says, “she hirself shal han her eleccioun”; that is, the formel shall choose for herself. (114) The fact that she chooses none of them for the present is significant in that it illustrates a view that to decline or postpone a proposal of marriage is permissible. Mutual feeling is the foundation of a proper courtship.

This is a counterpoint to the courtly ethics of *The Romance of the Rose*, which idealizes the sort of relationship that Chaucer mocks with the figure of Priapus. Chaucer, it should be
remembered, lived on the periphery of the court, and while the customs of the late fourteenth century were different than that of the late thirteenth, the *Romance* was still a hugely popular book. It is likely that Chaucer had some exposure to people engaged in courtly relationships; while it cannot be said that these relationships were anything like that depicted in the *Romance*, it is true that *The Parliament of Fowls* was written at approximately the time of King Richard II’s marriage to Anne of Bohemia, and may be a commentary on the courtship with its three suitors. Chaucer’s *Nature*, in giving the formel the power to choose, perhaps offers a pointed commentary on the courtship as Chaucer saw it from his position just outside the court. Enough of politicking, she seems to say; let the woman marry according to desire.

Thus Chaucer’s comment on the *Romance* takes shape as a critique of desire: desire directed towards the self, or self-gratification, leads to the temple of Priapus. Whether desire can be any other way; that is, focused outward, is a question he does not answer. The best he can do is to depict the formel as a creature currently without desire. The solution of mutuality is merely implied.

However, the idea of mutuality and reciprocity is interesting to Chaucer. Throughout his work, from *The Book of the Duchess* to *The Canterbury Tales*, he explores interpersonal relationships: the relationship between the speaker and the Black Knight in *The Book of the Duchess*, issues of social class and courtship in *The Parliament of Fowls*, interactions and tensions between various social classes in *The Tales*. Whether this has anything to do with the way he depicts autoeroticism as a negative, dangerous thing is arguable; it is sure, however, that he has an interest in relationships.

And not the least of those is the relationship between text and reader.
2: Beyond Sexuality: The Reader, Voyeurism and Layers of Narrative

The narrative style of both poems—namely, the first person—complicates the question of voyeurism by the speakers’ decisions to share their carnal glimpses with the reader. This sharing implicates the reader vicariously, through the act of reading. Thus the reader too becomes a voyeur. Jean de Meun saw this clearly, as his closing chapter of the *Romance of the Rose* is lush with obvious delight in its overt sexuality, and near the closing lines the speaker addresses the reader as “you.” (*Romance* 334) This “breaking the fourth wall” equates the reader and speaker as intimates; the retelling of this sexual experience has been to and for the reader.

Chaucer, naturally, is interested in this relationship. Jean de Meun’s narrative choices underscore the fact that in effect, the reader is always a voyeur, peeping into narratives from the outside rather than participating. Even when invited, as is the reader of the *Romance*, the experience is secondhand. A poem cannot “happen to” its reader; the action is bounded into the very words of the poem and must be understood as part of a static construct, akin to a painting or illumination. Given this property, the author has total control over what the reader sees, and Chaucer is clearly interested in this. In *The Parliament of Fowls*, he experiments with altering the layers of the narrative, so that the framing stories drop out—first the dream-guide Scipio, and then the speaker himself—so that all that remains is the parliament; the speaker appears afterwards only as a guide to the fowls’ rondel and in the closing stanza of the poem.

Beyond the formal experiments the *Romance* inspired him to, Chaucer extends the idea of autoeroticism, or narcissistic desire, into scholarship possibly distinct from sexuality. The speaker’s reading of Cicero is the frame of the poem’s narrative; moving from *The Dream of Scipio* to a dream of Scipio, the speaker is given a glimpse into the science of Love. As Scipio tells the speaker at the beginning of the dream vision proper, “Yet that thou canst nat do, yet
mayst thou see.” (Parliament 101) After the speaker’s adventures, he laments that he did not dream “som thing for to fare the bet,” that is, a concretely beneficial dream. Like Priapus, his vicarious, unfulfilled experience has left him frustrated.

Whether by “Love” Chaucer meant sexual relations or the emotion is unclear; this indistinctness complicates the discourse. (97) If by love he means sex, the reader is left with a commentary well summed up by the allegory of the temple of Priapus; however if he is referring to the emotional state, the poem is also critiquing the speaker’s solitary, academic pursuit of the question: what is love? As has been established, a reader cannot help being a voyeur, and so the speaker of the Parliament, studying love through books, ensnares himself in the framework of auto-obsession and frustration that Priapus and the speaker of the Romance find themselves caught in.

Chaucer’s reinterpretation of the Romance of the Rose reflects his affinity for nuanced, ambiguous and complex poems. His refusal to provide a clear conclusion to the Parliament’s argument vis-à-vis love and self-love gives the poem a sense of restraint, as well as a fitting dreamlike quality. His experiments with the poet’s and speaker’s relationship with the reader are echoed in other poems, such as The Book of the Duchess, another reinterpretation of the Romance, this time with the speaker having received the tale of the romance rather than having experienced it, and in The Canterbury Tales, which feature a multiplicity of narrators. This manipulation of poetic conventions highlights the power of the author, a power that was not privileged in the Middle Ages as it is today. All these suggest the development of an author who may be considered one of the first authors to embrace auctoritas in the modern vein.
Works Cited


'Out of Place:' Gangs, Delinquency, and Identity Formation in Los Angeles and Central America

Katherine Buckley
CSOC 316
Professor DeHart
April 6, 2009
Introduction

Human psychology naturally tends to organize itself around distinctions between the familiar and the unknown, the self and the Other. Within the ideal of modern, democratic, corporate, middle-class life in the United States today, there is little that can be distinguished as an "Other" so easily as the ethnic urban gang. Urban street gangs are a historically American phenomenon that has emerged in many other parts of the world in recent years (Manwaring 2005, Zilburg 2004). As gangs typically are associated with high levels of illegal activities and violent crime, there is widespread concern regarding the causes and consequences of these groups, and many efforts have been made to understand and explain this condition of Otherness. These narratives emerge from a variety of perspectives: security-law enforcement, political, moral, and socio-anthropological, for example. Given these different origins, there is considerable diversity of opinion about the roots, nature, threat, and impact of gangs all over the world, especially in the examination of different gangs in different regions.

One area of the gang phenomenon that has received much attention is the new transnational element of Hispanic gangs in Los Angeles and Central America. Started in Los Angeles by Mexican and Salvadoran immigrants, in part to protect themselves from the already-existing L.A. gang culture, the 18th Street (Chicano/a) and Mara Salvatrucha 13 (Salvadoran) gangs have now spread to many Latin American nations, including El Salvador, Nicaragua, Guatemala, and Mexico. With membership estimations ranging from 70,000 to 300,000, these gangs have become dynamic forces with an undeniable impact – generating a strange mélange of media hysteria, government crackdown, and
academic interest (Boerman 2007). Many mainstream explanations for the rise of gangs include concerns about poor parenting (Yablonski 2001), poverty (Cruz 2005), street socialization, and attitudes toward police (Freng 2007). A unique factor in the case of 18th Street and MS 13 is deportation – the tactic in which the U.S. deports non-citizen gang members back to their countries of origin – which is universally cited in explaining the rise of these particular transnational gangs and their expansion into Central America. This paper acknowledges and expounds upon these prevailing accounts; the primary focus, however, is to explore the ways in which gangs – specifically, the transnational 18th Street and MS gangs – constitute a zone of social abandonment within the United States and El Salvador.

As a beginning framework, I draw from the work of anthropologist João Biehl and his theory of social abandonment. In his work *Vita: Life in a Zone of Social Abandonment*, Biehl maps the process of such abandonment by tracing the life of one woman, named Catarina, and her path to social ostracism and exclusion. Central to his theory is the idea that a status of "ex-humanness," a state of non-personhood and invisibility, must be reached in order for society to abandon a group or individual; additionally, that the processes of social change constantly offer new and altered ways in which a person can lose her perceived humanness (Biehl 2006). Using Biehl's theory as a framework, this paper delves into the historical and ecological factors that consistently strip away the personhood of potential gang members. Going beyond the oft-tread areas of gang-factor explanations, and in contrast to the above societal perceptions, I also explore the ways in which the Mara Salvatrucha and 18th street gangs in both the U.S. and El Salvador are an attempt by members to claim lost identities and re-establish
"humanness" on their own terms. With this gang identity formation, however, comes risks of visibility-through-delinquency and the idea that gang membership is both a result and a cause of perceived "ex-humanness" in a perpetuating cycle. Lastly, the paper closes with some recommendations for social change which could positively influence the gang phenomenon.

**Factors associated with "ex-humanness" and gang membership in the United States**

As both of these gangs found their origins in the United States, I begin with a discussion of the ecological and historical factors that facilitate gang membership in the Los Angeles area. Contrary to the popular notion of the United States as a land of opportunity, immigrant and ethnic populations often face daunting barriers to social mobility and integration. Often times these groups are greeted by "social neglect and ostracism, economic marginalization, and cultural repression" (Vigil 2002, 162).

Immigrant or minority populations moving to large cities are often relegated to the cheapest areas of town and are frequently grouped together due to informal segregationist policies; thus, the result is that most ethnic groups are highly territorialized and cut off from areas of high opportunity within the city (Vigil 2002). In a study on immigrant populations and ethnic mobility, researchers found that, consistently, "young Latino men are...mired in the lowest rungs of the U.S. labor market, with nearly two out of three employed in low-wage labor" (Rumbaut 2008, 4). In running a model to determine significant factors for social success, this study also discovered that "Mexican, Salvadoran, and Guatemalan ethnicities retain negative significant effects on educational attainment," which in turn is one of the key determinants of ethnic mobility (Rumbaut 2008, 35). Therefore, there are strong structural forces that are preventing these Latino
immigrants from participating in education, lucrative employment, and other opportunities.

These findings indicate that so many of the attributes that the United States associates with success and value (i.e. true personhood and humanity) - such as education, upward mobility, and a career - are consistently denied these Central American immigrant populations. Ethnographer James Vigil attempts to explain these overlapping social failures in a theory of "multiple marginality," in which it is the "joint actions (or inactions)" of different societal institutions such as schools, the market, the family, and law enforcement that allow the issue to continue and even "make the problem worse" (2002). From these conditions, one can see that poverty itself is not what strips away a person's humanity and sets them on the path to gang membership; rather, it is constant marginalization, exclusion, blocked access to legal opportunities to change the situation that truly dehumanizes.

These problems are further exacerbated by the complex immigration codes, the legacy of historical and political conditions, and the difficulty in obtaining legal status for these immigrants. Many of the Salvadoran immigrants in Los Angeles today left El Salvador during the horrific civil war years that lasted from the late 1970s until 1992 (Waldinger 2008). Because the Reagan Administration saw Central America as vital to its Cold War political strategy, the United States government gave massive amounts of aid, political strategy, and military support to Central American forces fighting leftist groups, such as to the oppressive military junta in El Salvador suppressing the leftist FMLN or the Contras battling the new revolutionary government in Nicaragua (Smith 1996). Due to these political decisions and the need for delicate handling of the publicity
regarding Central American intervention, the Reagan Administration was careful to avoid recognizing or condemning the Salvadoran government's human rights abuses (Smith 1996, Waldinger 2008). This meant that the U.S. was unable to grant refugee status to the thousands of Salvadorans that arrived in the U.S. to escape the pervasive violence and seek more stable economic opportunities, as it would have meant the acknowledgement that the Salvadoran government was perpetrating politically motivated violence against its civilian population (Waldinger 2008). Denied refugee status, these Salvadoran immigrants were also excluded from many of the legal protections provided by the 1986 Immigration Reform and Control Act, were granted asylum in miniscule proportion to population (around 3%), and were left only with the Salvadorans with Temporary Protected Status Act of 1990 – a measure allowing Salvadorans "to work and reside legally in the United States on a short term basis, without, however, providing a door to permanent legal status" (Waldinger 2008, 849). In a nation that values citizenship, voting rights, and individual political agency as part of a person's worth, this denial of legal recognition and the rights it entails is a powerful denial of personhood in the eyes of the state.

The ramifications of this illegality and consequent lack of perceived humanness within the United States has left the Central American immigrant populations with few options. Upon entering the United States, these groups faced the hostility of an entrenched gang culture that extended from other ethnic groups all the way to the "gang-like practices that were structurally embedded within the police department" (Zilburg 2007, 45). Without any legal protection, Central American – particularly Salvadoran – immigrants had to rely on their own agency to adapt to Los Angeles street culture.
Research by ethnographer Elana Zilburg has "documented how the notorious elite gang abatement unit, Community Resources Against Street Hoodlums (CRASH) in the Rampart Division, worked actively to criminalize everyday life practices of immigrants," further restricting their abilities to support themselves through legal means (Zilburg 2007, 45). Public scandal has erupted over the tactics employed under the Rampart Division, yet it remains true nonetheless that illegal or nonpermanent residents have no rights or personhood from the perspective of the state. Thus, not only do these groups lack legal recourse, but additionally "an immigrant's legal status is a critical factor in shaping mobility – and an unauthorized status can affect virtually every facet of an immigrant's life" and "block access to opportunity" (Rumbaut 2008, 11, 38). This creates a vicious cycle of marginalization, dehumanization, criminalization, and re-marginalization that funnels immigrant youth into gang membership, which, like Catarina's abandonment, is managed at "the vortex of public institutions" (Biehl 2005, 252). With 18th Street and MS gangs, the deportation element adds a new dimension which I will discuss later in the paper.

**Factors associated with "ex-humanness" and gang membership in Central America**

Gang membership in Central America has a structural, ecological, and historical narrative, as it does in the United States. Contrary to the popular notion that street gangs sprang into existence with the influx of U.S. deportees, Central American gangs, or *pandillas*, actually emerged during the war years as an effort to control certain neighborhoods and defend against state, rebel, and paramilitary forces (Cruz 2005). The change that occurred with the implementation of deportation was a consolidation of smaller neighborhood groups, or *clicas*, into subsets of the larger 18th Street or MS gangs.
(Cruz 2005). The continuation and proliferation of these gangs may be seen as "the product of a concurrence a great number of factors that have been socially and historically determined" (Cruz 2005, 1159, my translation). For example, the socioeconomic status of the poor is "precarious" at best, as recent neoliberal reforms in El Salvador and other Central American countries have resulted in the reduction of social programs, increased informalization of the economy, and loss of dependable jobs (Álvarez 2007). Researcher José Miquel Cruz depicts gang risk factors as an "ecological model" of overlapping societal, communal, relational, and individual forces – such as extreme social and economic exclusion, violent cultural norms, disordered urban environments, and difficulties in identity formation in these conditions (2007). He discusses the signs of El Salvador's poor as a socially abandoned group, from the fact that only ten percent of Salvadoran gang members could obtain stable employment to the obvious signs of decay and inattention within urban barrios (Cruz 2007).

Correspondingly, he writes that gangs "flourish in those districts (slums) where poverty manifests itself in nonexistent or low-quality social services" (Cruz 2007, 1162, my translation). The relations which most urban Salvadoran youth have with the state is overwhelmingly one of absence and abandonment: their public spaces are deteriorated and their neighborhoods are home to more bars, brothels, and crack houses than parks or community centers (Cruz 2007, DeCesare 1998). In other words, in both the United States and Latin America, "human-rights law generally protects only civil and political rights, as opposed to economic and cultural rights…such as the right to employment, healthcare, and cultural traditions" (Coutin 2007, 156). This structural and ecological
denial of rights constantly strips Salvadoran youth and potential gang members of value, personhood, or any rightful place within a transitioning state.

Into these precarious socioeconomic conditions is added the historical legacy of El Salvador's civil war. Upon the signing of the 1992 Peace Accords, the armed conflict officially ended, but many of the economic inequality issues which had spurred its conception remained unchanged – leaving the poor of El Salvador in largely the same invisible, disenfranchised position as in the years before the war. This means that as thousands of de-mobilized guerilla and paramilitary troops floundered in their attempts to reintegrate into society, with little to no state support, their existing support structures were violent and militaristic (Coutin 2007). One can see this reflected in the language of one researcher speaking about his experiences with gangs: "the extreme degree of group affiliation is similar to that of armed service activities during wartime. The platoon, or this case, the local gang, is worth dying for" (Stretesky 2007, 98). This legacy from the war years is facilitated still further by the plethora of arms available, as "the region was awash with weapons leftover from decades of civil conflict" (Boerman 2007, 36). This combination of unresolved grievances and resentments, a generation raised amidst pervasive normative violence, a war-wearied nation, and the image of gun-toting youth, called maras or pandilleros, has led to a phenomenon paradoxically "produced by destructive forces" which allows the subjects – young, potentially violent pandilleros – to be dehumanized even further in the public eye (Coutin 2007).

'Falling between countries:' the dehumanizing factor of deportation

Those who are deported back to El Salvador – overwhelmingly young, poor, and male – face a unique set of disorienting and dehumanizing circumstances which create
prime candidates for new or continued gang membership. Given that inner-city identities are often strongly linked with territories and spatial ties, these deportees "who have complex belongings…are stripped of certain memberships" by this removal (Coutin 2007, 18). Further deepening these tensions, often the deported youths arrived at a young age in the United States years ago, speak little or different forms of Spanish, and know even less about El Salvador – despite its being their legal country of origin (Zilburg 2004). Many lack proof of Salvadoran citizenship once they arrive, or are "dumped" at the Salvadoran airport in the words of one NGO worker, and thus they become "doubly illegal," with no rightful belonging in any country (Coutin 2007). The deportation act is in itself also "a strong form of rejection, a withdrawal of rights, connections, and services – in short, an abandonment," as Salvadoran youths are denied even the marginal existences and identities they have provided for themselves in Los Angeles (Coutin 2007, 33). As discussed in the above sections, the marginalization and abandonment does not end once they reach El Salvador, as Salvadoran "post-war democracy is deeply marked by the exclusion of those already excluded by U.S. democratic society. Therefore, gang youth mark the doubly untenable hyphenation between nation-states" (Zilburg 2007, 48). Having their rights, possible citizenship, humanity, and even presence denied by their country of choice; and facing no support in their country of origin; these youths are "out of place, and therefore not fully present" and so they "fall between countries" (Coutin 2007, 44). They have reached the status of transnational social and political "ex-human." In this light, gangs and gang membership appear to be the attempt to re-construct a human identity from this invisibility, denial, and fragmentation.

**Gangs as identity formations and agents of resistance**
This view involves a transition from seeing gangs as purely pathological into a perception of gangs as instruments of resistance, or "innovative subcultures of meaning-making, ambivalence, and self-organization" which "break the shrouds of race and ethnic invisibility" (Brotherton 2008, 61, 66). One important aspect of street gang culture is the prominent use of symbols, tattoos, rituals, graffiti, music, slang and other aesthetic forms of expression (Brotherton 2008, Álvarez 2007). A resistance-oriented perception of gangs reads these practices as "struggles for representation" and the formation of new individual and collective identities (Brotherton 2008, 62, Álvarez 2007). Such usage also allows gang members to highlight their social status, transforming social stigmas into symbols of a strong identity and redefining power relationships and dependencies (Álvarez 2007). Like Biehl's emphasis on Catarina's writing, this view sees gang membership as an active way to combat abandonment and to "[produce] their own texts" (Brotherton 2008, 67). Most importantly, these connections re-establish personhood and a secure sense of self for gang members. This is shown in the comment by one gang member interviewed in prison, as he notes "Every man [in a gang] is treated as a man until proven different. We see you as a man before anything" (Stretesky 2007). One can see the importance of the validated manhood (i.e. personhood) within the group dynamic, and given the legacy of marginalization and denial out of which most of these members emerge, this is a powerful force. From this perspective, one can also read the presence of guns and violence not only as a practical response to the hazards of street life, but also as active efforts to maintain a reputation, group identity, and personhood within the gang. One researcher observed that "according to gang members we talked to, disrespect, or rejection of self-professed identity by others, often
was the cause of violence" and that "guns are tools that aid in identity formation and impression management" (Stretesky 2007, 104, 108). Gangs, guns, and violence as agents of resistance, then, carry some powerful attractions and tools for their members.

Additionally, gangs are not always mere vehicles of perpetuation, condemning their members to a life sentence on the streets. Many produce action that extends beyond turf wars and crimes; for example, American gangs have engaged in protests over police brutality, the death penalty, and the Iraq war (Brotherton 2008), while their Central American counterparts participate in support of rival political parties in the form of rallies and the like (Zilburg 2007). Recognizing this potential for widespread action could be enormously impacting of future gang-centered social policy efforts.

Visibility through delinquency and "the new insurgency"

The construction of gang-related identities, however, carries problematic consequences: in the eyes of society at large, these identities are only visible through their delinquency. This creates the danger that "structural conditions and historical processes come to be situated in persons" (Coutin 2007, 165). Much like Biehl's description of Catarina as a "pharmaceutical being" and the ways in which this justified her abandonment (2005), this perception of gang-delinquency-identity roots the origins of the problem in the pathologies of the subjects – a mindset which implies the problem must be cut out of society rather than rehabilitated or reintegrated. We can see this phenomenon at work in the different suppression tactics and public discourse of increasing Otherness surrounding gangs in both the United States and Latin America.

In the United States, the shift to a pathological view of gangs began around the 1970s, with new academic definitions of gangs that included explicit references to
outsiders' perceptions of gangs and delinquency as inherent to their composition (Brotherton 2008). The trend has continued, continually repositioning gangs not as *symptoms* of larger societal ills, but as *causes* of a wide array of social dysfunctions, including terrorism, organized crime, prison culture, and school decay (Brotherton 2008). Correspondingly, increased anti-immigration sentiment has been matched with an increased association of emigration as no longer a product but a cause of violence (Coutin 2007). Referred to as an "urban insurgency," public discourse surrounding gangs has taken on highly militaristic tones, calling the situation "nonstate war" and explicitly listing gang threats along side those of "Osama bin Laden's terrorists, Maoist insurgents…and warlords" (Manwaring 2005, 7). The enforcement tactics reflect this mentality of a "zero-sum game in which there can only be one winner or no winners," with heavy incarceration and deportation rates (Manwaring 2005, 39).

With the support of the United States, many Central American states have embarked upon similarly harsh tactics, such as El Salvador's Mano Dura (Tough Hand) legislation. Among the provisions of this legislation is the "illicit association" regulations, which have criminalized gang membership and allow for the arrest of those merely suspected of being in a gang (Boerman 2007). Described as "tactics that…place criminals outside the collectivity of citizens (indeed, of humans) who have rights," these suppression techniques further dehumanize gang members and prevent any meaningful rehabilitation or reconciliation (Coutin 2007). These tactics also bear eerie similarity to those used against leftist guerrillas during the civil war years, leading some to believe that "gangs have replaced guerrillas as the new 'insurgency'" for the government (Coutin 2007, 168). For example, newspapers regularly publish the pictures, gang nick names,
and legal names of wanted gang members – just as newspapers used to publish death threats against the opposition – and paramilitary, vigilante death squads have mobilized against gang members with, at times, the tacit support of government forces (Zilburg 2007). Given that gang identity-formation is often the only recourse left to these young Salvadorans, these harsh measures criminalize their very identities and perpetuate their ex-humanness in the eyes of the state and the public.

Proposed social change and conclusions

Given popular perceptions of the gang threat, "current strategies are best characterized by piecemeal measures that target symptoms and are rooted in a combination of 'Moral Panic' and elected officials' efforts to demonstrate a 'get tough on gangs' stance" (Boerman 2007, 44). No real comprehensive efforts have been made to address the problem in a "holistic manner," additionally, research has found that Central American 18th Street and MS gang members "have become more committed to a gang lifestyle because Mano Durisma emphasizes repression to the virtual exclusion of rehabilitation and social reinsertion programs that could provide them the assistance they need" (Boerman 2007, 37, 46). Thus, any meaningful social change for gang members would have to be rooted in a commitment to re-humanizing and re-personalizing gang members through personal connections, amnesty, and increased legal opportunities.

There are a small number of success stories in the field of gang studies related to 18th Street and Mara Salvatrucha members, such as churches committed to rehabilitation through personal relations with the pandilleros and programs such as Homies Unidos in San Salvador, which acts as a support service for deported gang members and encourages gang peace activism (Gómez 1999, DeCesare 1998). In order for these organizations to
have success, however, larger societal changes must take place in the de-criminalization of gangs as entities and the comprehensive investment of social services and legal options in low-income neighborhoods, ghettos, and barrios. In Barcelona and Geneva, authorities actually legitimized the Latin King/Queens and Ñeta gangs as "legally recognized 'cultural associations','" thereby bringing them into the realm of cultural integration and legality (Brotherton 2008, 66). While such a radical measure may be slightly unrealistic for the Americas at this point, smaller de-criminalizing steps could still help. A publicized statement, for instance, that any gang members seeking intervention help would not be questioned for intelligence about their former gang and its activities could alleviate the fear of gang-sponsored retribution, which is a major obstacle for potential defectors. Immigration reform and the cessation of deportation tactics would also come closer to the official recognition of personhood necessary to integrate current and potential gang members into legal society.

In this manner, viewing gangs through the lens of social change, possibilities for "ex-humaness," and social abandonment carries some important consequences. It creates scenarios in which we can envision reforms such as those mentioned above, rather than zero-tolerance suppression tactics that only create overwhelming flows of incarceration or transport the problem somewhere else. More importantly, however, such a framework has the potential to re-humanize the gang members, to catch glimpses of the familiar within the Other, and we can view their actions as attempts to reclaim their ignored or denied identities in an often hostile world.


Orchid Fragrance Complexity as a Mechanism for Euglossine Bee Pollinator Specialization

Luci Moore

Department of Biology, University of Puget Sound

ABSTRACT

Neotropical orchids of subtribes Stanhopeinae and Catasetinae are exclusively pollinated by euglossine bees (Euglossini). This study determines whether orchids present specific combinations and proportions of chemical odors in order to attract a limited subset of euglossine bee species, thereby avoiding hybridization that may result from the attraction of too many pollinators. Chemical baits of cineole, benzyl acetate, methyl salicylate, cineole/benzyl acetate (a Stanhopea tricornis fragrance analogue), and cineole/methyl salicylate/methyl benzoate (a Catasetum gnomus fragrance analogue) were used to attract fifteen species of euglossine bees in the San Luis Valley, Monteverde, Costa Rica. The diversity of bee species attracted to the cineole/benzyl acetate solution was significantly lower than either cineole or benzyl acetate (Shannon-Weiner index; for cineole/benzyl acetate: H' = 0.89; for cineole: H' = 1.91; for benzyl acetate: H' = 1.82; for cineole/benzyl acetate and cineole: F = 4.89, df = 68.00; for cineole/benzyl acetate and benzyl acetate: F = 5.66, df = 64.29, p < 0.05). The diversity of species attracted to the cineole/methyl salicylate/methyl benzoate solution was significantly lower than cineole (Shannon-Weiner index; for cineole/methyl salicylate/metil benzoate: H' = 0.82; for cineole: H' = 1.91; F = 6.16, df = 61.25, p < 0.05). The results provide evidence that orchid fragrance complexes are designed to attract specific euglossine species that are both effective pollinators and specialized enough to reduce risk of interspecific outcrossing.

RESUMEN

Las orquídeas neotropicales de las subtribus Stanhopeinae y Catasetinae son exclusivamente polinizadas por abejas euglosinas (Euglossini). Este estudio determinó si las orquídeas presentan combinaciones y proporciones de olores químicos específicos con el fin de atraer un grupo limitado de abejas euglosinas, para evitar hibridización que puede resultar de la atracción de muchos polinizadores. Sebos de cineole, bencyl acetato, metil salisilato/metil benzoato (análogo de la fragancia de Stanhopea tricornis), y cineole/metil salicilato/metil benzoato (análogo de la fragancia de Catasetum gnomus) se usaron para atraer quince especies de abejas euglosinas en el San Luis Valley, Monteverde, Costa Rica. La diversidad de especies de abejas atraídas al cineole/bencyl acetato fue significativamente menor que el cineole o benzyl acetato (Indice Shannon-Weiner index; cineole/benzy acetato H' = 0.89; for cineole H' = 1.91; for benzyl acetato H' = 1.82; for cineole/benzy acetato and cineole F = 4.89, df = 68; for cineole/benzy acetato and benzyl acetato F = 5.66, df = 64.29; p < 0.05). La diversidad de especies atraídas al cineole/metil salicilato/metil benzoato, fue significativamente menor que el cineole (Indice de Shannon-Weiner para cineole metil salicilato/metil benzoato H' = 0.82; for cineole H' = 1.91; F = 6.16 df = 61.25, p < 0.05). Los resultados presentan evidencia que los complejos de fragancias de las orquídeas esta diseñado para atraer especies específicas de abejas euglosinas que sean polinizadores efectivos y suficientemente especializados para reducir el riesgo de exocruzamiento interespecífico.

INTRODUCTION

Many plants depend on their ability to attract pollinators so that outcrossing may occur, thereby increasing genetic variation in the population (Dressler 1981). In the tropics, plant species are typically rare with scattered distributions, making it necessary to specialize with specific animal pollinators to ensure that pollen will effectively reach conspecifics (Schatz 1990). As vessels of
both pollen distribution and reception, flowers are characterized by specific morphological and chemical traits that result from coevolution with their respective pollinators (Dressler 1993, Raguso 2008). By catering to the preferences of their pollinator organism, plants receive a means for outcrossing via the resulting pollen removal. In turn, pollinators use the flower rewards of nectar, pollen, etc. to maximize their own fitness, making this evolutionary relationship vital for both plant and animal (Raguso 2008).

Some of the most interesting and highly evolved pollination syndromes are those of Family Orchidaceae. Orchids comprise the most species rich of any plant family, with 20,000 species known worldwide and 7,000 in the Neotropics (Roubik & Hanson 2004). Despite high biodiversity, orchids have particularly low biomass, scattered distributions, and inconspicuous microhabitats, necessitating some of the most highly coevolved plant-pollinator relationships known (Raguso 2008). Orchid pollinators seek out conspecifics in search of nectar (the most common reward), oil, pseudopollen, or perfume, and therefore provide a mechanism for the transfer of pollinia over long distances and varied microhabitats (Dressler 1993, Raguso 2008).

The interaction between Neotropical orchids and male euglossine bees (Family Apidae; tribe Euglossini), or orchid bees, is a well-studied example of a specialized orchid-pollinator relationship and is estimated to have arisen repeatedly over the last 20 million years (Engel 1999, Roubik & Hanson 2004). As a result of this long time period, male euglossine bees have coevolved extensively with their orchid partners and currently pollinate up to ten percent of Neotropical orchid species from subtribes Catasetinae, Stanhopeinae, Lycanstinae, Zygopetalinae, and Oncidiinae (Ramirez et al. 2002; Roubik & Hanson 2004). This highly evolved pollination syndrome is unique in that (1) each partner confers greater reproductive fitness to the other and (2) fragrance is the currency (and sole reward) involved in these mutualisms. Thus while a male bee is collecting fragrances for use in mate attraction, the orchid is increasing its chances of outcrossing by transferring pollinia to the body of the bee (Dressler 1993; Roubik & Hanson 2004).

Though outcrossing is the essential goal of pollination from the perspective of the orchid, there is risk of hybridization via uptake of pollinia from dissimilar species (Roubik & Hanson 2004). Evolutionarily, hybridization is harmful in that it leads to homogenization of species, thereby decreasing genetic variation and leading to simpler systems that lower population resilience and decrease community function. Therefore, in order to coexist in the same habitat and remain separate species, orchids utilize a variety of reproductive isolating mechanisms, including temporal strategies as well as complex and varying floral morphology (Dressler 1981). Given such mechanisms, only euglossine bee species that are of a certain size or that exhibit particular behavior can successfully transfer the pollen of specific orchids. However, since many species of euglossine bees may visit a variety of orchid species for fragrance collection, the chance of transgenic pollinia uptake and subsequent hybridization may be increased. To avoid hybridization, orchid species may produce different fragrance combinations and/or proportions of combinations to further narrow the specificity of bee species, therefore using fragrance as yet another reproductive isolating mechanism (Hills et al. 1972; Roubik & Hanson 2004, Raguso 2008).

There is strong evidence to suggest that orchids produce and bees collect specific fragrance combinations. At least 60 compounds have been identified in the odors of euglossine orchids, but individual orchid species often contain fewer than 12 of these, with domination by one or two chemical components (Gerlach & Schill 1991; Eltz et al. 2005). Also, it is well documented that euglossine males display interspecific fragrance bouquet preference (Hills et al.
1972; Roubik & Hanson 2004; Ackerman et al. 2005; Eltz et al. 2005). However, past studies have shown contradictory results in testing the preference by male bees for chemical baits of single or multiple fragrances (Dodson et al. 1969; Schiestl & Roubik 2003). Modifier chemicals (which are found in many orchid fragrance complexes, but do not by themselves act as attractants) such as alpha-pinene are known to reduce attractant potential, but it is not as certain whether a combination of successful attractants also alters the composition of pollinators. This study set out to determine whether orchids, specifically Stanhopea tricornis and Catasetum gnomus of Costa Rica, present specific combinations and proportions of chemical odors to attract a limited subset of euglossine bee species. These two orchid species serve as representatives of the subtribes Stanhopeinae and Catasetinae, the only subtribes pollinated exclusively by male euglossine bees (Williams & Whitten 1983). I predicted that more complex combinations of fragrances would attract fewer euglossine bee species as a mechanism to attract a limited set of effective pollinators, thereby increasing chances of outcrossing and reducing chances of orchid hybridization.

**METHODS**

**General**

This study was conducted in the Puntarenas province of Costa Rica in the San Luis Valley, Monteverde, Costa Rica (1000 meters above sea level). Sampling was done in primary forest from 800 to 1200 (period of greatest fragrance collection by male euglossine bees, Williams & Whitten 1983) for 15 days from October 27 to November 16, 2009. My sampling consisted of two separate parts (1) Fragrance and (2) Visitation of species.

**Fragrance Combinations**

In order to test for specificity of fragrances and pollinator attraction, I mimicked the fragrance combination of two orchid species, Stanhopea tricornis and Catasetum gnomus. Stanhopea tricornis produces a fragrance that is one part cineole and 39 parts benzyl acetate (Dodson et al. 1969), so I mixed 0.2 mL cineole and 7.8 mL benzyl acetate to create its fragrance analogue. Catasetum gnomus produces a fragrance that is 59% methyl salicylate, 10% cineole, and 9% methyl benzoate (Hills et al. 1972), so I created the analogue with 1.5 mL methyl salicylate, 0.25 mL cineole, and 0.23 mL methyl benzoate. For each orchid species I conducted trials for each separate fragrance and for the specific combination of fragrances.

**Visitation of Species**

Only one fragrance or combination was tested in a day. For each trial, I saturated cotton balls with three drops of the appropriate fragrance or solution, hung them from shrubs, and identified the species that visited the bait. Baits were replenished with fragrance halfway through the trial period. Some euglossine bees species pairs were difficult to distinguish in the field and were recorded as either/or, including Euglossa cybelia and maculilabris, Euglossa deceptrix and tridentata, Euglossa dodsoni and erythrochlora, and Eulaema meriana and bombiformis. Each bee observed was marked with a paint pen to avoid recounts. Abiotic conditions, including
temperature, humidity, and general weather conditions (sunny, windy, raining, etc.) were also recorded with each observation.

**Statistical Analysis**

A template was used to calculate Shannon-Weiner diversity index for the euglossine bee community visiting each chemical fragrance. These values were compared using modified t-tests.

**RESULTS**

**Statistical Results**

A total of 191 euglossine bees were observed across 15 species of all four genera (Table 1). The most frequent visitors to the fragrance cineole were *Euglossa imperialis* and *Euglossa cybelia/maculilabris* and the most frequent visitors to benzyl acetate were *E. imperialis*, *Euglossa deceptrix/tridentata*, and *Eu. meriana*. *Eu. meriana* was the most frequent visitor of cineole/benzyl acetate and, along with *E. imperialis*, to methyl salicylate and cineole/methyl salicylate/methyl benzoate. *Eul. championi* and *E. dodsoni/erythrochlora* were both attracted to cineole and benzyl acetate when these chemicals were presented alone, but not in combination. *Euglossa championi* was similarly attracted to methyl salicylate alone, but not to the cineole/methyl salicylate/methyl benzoate solution (Table 1).

For the test of *S. tricornis* orchid fragrances (cineole, benzyl acetate, and the cineole/benzyl acetate analogue solution), the diversity of species that visited cineole alone was not different from the diversity of species that visited benzyl acetate alone (Shannon-Weiner index; for cineole: $H' = 1.91$; for benzyl acetate: $H' = 1.82$; $F = 0.62$, df = 33.80, $p = 0.54$; Figure 1). Both cineole and benzyl acetate alone attracted a greater diversity of species than the cineole/benzyl acetate solution (Shannon-Weiner index; for cineole: $H' = 1.91$; for benzyl acetate: $H' = 1.82$; for cineole/benzyl acetate: $H' = 0.89$; for cineole and solution: $F = 4.89$, df = 68.00; for benzyl acetate and solution: $F = 5.66$, df = 64.29, $p < 0.05$).

For the test of *C. gnomus* orchid fragrances (cineole, methyl salicylate, methyl benzoate, and the cineole/methyl salicylate/methyl benzoate analogue solution), the diversity of species that visited cineole alone was greater than the diversity that visited methyl salicylate alone (Shannon-Weiner index; for cineole: $H' = 1.91$; for methyl salicylate: $H' = 0.96$; $F = 5.04$, df = 64.86, $p < 0.05$; Figure 1). Diversity of visitors to cineole was also greater than the diversity of visitors to the cineole/methyl salicylate/methyl benzoate solution (Shannon-Weiner index; for cineole: $H' = 1.91$; for cineole/methyl salicylate/methyl benzoate: $H' = 0.82$; $F = 6.16$, df = 61.25, $p < 0.05$). Methyl salicylate and the cineole/methyl salicylate/methyl benzoate solution did not attract different species diversities (Shannon-Weiner index; for methyl salicylate: $H' = 0.96$; for cineole/methyl salicylate/methyl benzoate: $H' = 0.82$; $F = 0.97$, df = 72.43, $p = 0.33$).

For other comparisons, the diversity of species attracted to benzyl acetate alone was greater than the diversity attracted to methyl salicylate alone as well as to the cineole/methyl salicylate/methyl benzoate solution (Shannon-Weiner index; for benzyl acetate: $H' = 1.82$; for methyl salicylate: $H' = 0.96$; for cineole/methyl salicylate/methyl benzoate: $H' = 0.82$; for benzyl acetate and methyl salicylate: $F = 6.07$, df = 74.84; for benzyl acetate and cineole/methyl
There was no difference between the diversity of species attracted to methyl salicylate and the cineole/benzyl acetate solution (Shannon-Weiner index; for methyl salicylate: $H' = 0.96$; for cineole/benzyl acetate: $H' = 0.89$; $F = 2.31$, df = 65.05, $p = 0.15$). The diversity of euglossine bee visitors to the cineole/benzyl acetate solution was greater than the diversity for the cineole/methyl salicylate/methyl benzoate solution (Shannon-Weiner index; for cineole/methyl salicylate/methyl benzoate: $H' = 0.82$; $F = 2.31$, df = 60.77, $p = 0.02$; Figure 1).

The range of ambient temperatures with the highest species richness was between 21 and 24 °C (Figure 2) and with the highest species abundances was between 20 and 24 °C (Figure 3).

**Additional Observations**

Of the 191 bees observed, ten were carrying pollinia. All bees with pollinia were *E. meriana/bombiformis* except for one *Eufrisea surinamensis*. Seven bees carried the pollinia attached to their cleypeus, which could have been from orchid genera *Aspasia*, *Notylia*, or *Thrichophilia* (Roubik & Hanson 2004). Three bees, including *E. surinamensis*, carried the pollinia on the frontal thorax, indicating that the visited orchids could have been *Sobralia*, *Houlettia*, and/or *Kegeliella* genera.

**DISCUSSION**

Each orchid analogue experiment supported my original hypothesis. For the *Stanhopea* analogue, cineole and benzyl acetate by themselves attracted a greater diversity of bees than when the chemicals were combined in specified proportions found in *S. tricornis*. *Eulaema meriana*, the known pollinator of this orchid, was the most frequent visitor to the analogue solution. Four *Euglossa* species also visited the cineole/benzyl acetate baits, but these are all too small to be effective pollinators for *S. tricornis* (Hills et al. 1972). It is likely that these bees visited because the true fragrance composition in nature is much more complex and includes modifiers such as alpha- and beta-pinene that may normally ward off such visitors. Furthermore, given that cineole and benzyl acetate attract the same diversity of euglossine bee species, it is unlikely that fewer bees were attracted to the combined solution due to a difference in concentration.

For *Catasetum*, the combination of cineole, methyl salicylate, and methyl benzoate found in *C. gnomus* attracted a lower diversity of bees than cineole alone. As with the *Stanhopea* analogue, the most frequent visitor was *E. meriana*. *Euglossa imperialis* was also a relatively frequent visitor. What is surprising is that the diversity of bees attracted to methyl salicylate was not statistically different from the cineole/methyl salicylate/methyl benzoate solution. This could be due to the frequency of methyl salicylate in nature. Fourteen of the 39 compounds produced by *Catasetum* orchids have been identified with gas-liquid chromatography. Of the 22 *Catasetum* species analyzed by Hills et al. (1972), cineole is present in 64 percent of the species compared to methyl salicylate, which is only present in 14 percent of the species. Cineole is also the dominant component in 14 percent of the species while methyl salicylate is the dominant fragrance in 9 percent. Furthermore, in a meta-analysis on orchid floral fragrances as euglossine bee attractants done by Williams and Whitten (1983), 60 chemicals were identified and rated in attractiveness and abundance. Cineole was marked as a good (as opposed to moderate)
attractant, is known to be present in a relatively large number of orchid species, and makes up 21 to 90 percent of the fragrance composition of most species in which it is present. Therefore cineole is more commonly found in nature than methyl salicylate and acts as a stronger attractant. It is reasonable to conclude that the inclusion of methyl salicylate in a floral presentation already acts to attract a limited subset of euglossine species in comparison to cineole. Further studies should be done to test whether the assumption that frequency in nature and attractive ability are indeed positively correlated.

For the chemical baits presented, simple and complex alike, *E. meriana* and *E. imperialis* made up a large portion of the bee visitors. It is possible that the orchid fragrances are not only selectively attracting species, but that these bees species are simply more generalist. For *E. meriana* individuals with pollinia, the placement on the body suggests that these individuals received the pollen from at least two and at most six different orchid genera, none of which are *Catasetum* or *Stanhopea*. Furthermore, it is not unusual for certain euglossine species to be attracted to a wide variety of odors. In nature, euglossine males have been observed collecting odors from a diversity of locations, including rotting fruit and wood, tree bark, and exposed roots (Ackerman 1989). Furthermore, researchers often successfully attract euglossines using chemicals that have not been found in natural orchid fragrance complexes (e.g. vanillin, skatole, p-crestyl acetate) (Williams and Whitten 1983). One study even reports technical grade DDT used for malaria control as an attractant for male *Eufriesea purpurata* in Amazonian Brazil (Roberts et al. 1982). Along with possibly being more generalist in fragrance preference, *E. meriana* and *E. imperialis* bees are larger in body size and may be able to better withstand abiotic conditions of rain, wind, or temperature. It would be interesting to test this by controlling for scent preference and observing whether fewer of the small *Euglossa* bees are attracted in harsher weather conditions.

Both *E. championi* and *E. dodsoni/erythrochlora* were attracted to cineole and benzyl acetate separately, but not to the combined solution. *Euglossa championi* was also attracted to methyl salicylate, but not to the cineole/methyl salicylate/methyl benzoate solution. This is not necessarily a rare occurrence. In a previous study, Williams and Calaway (1972) found that *E. meriana* is attracted to cineole and methyl salicylate separately, but is attracted to the combination in very low numbers. Further study is needed to determine by what mechanism a combination of fragrances reduces attractiveness. Currently, the most convincing hypothesis is that reduction in attraction is due to a synergistic inhibition of receptor responses at the peripheral and central nervous system (Williams & Calaway 1972; Schiestl & Roubik 2003). This could occur via binding interactions, where each chemical inhibits the other from binding to a receptor (Schiestl & Roubik 2003). The fact that two attractive chemicals become unappealing to certain bee species when combined demonstrates the importance of chemical blends and proportions in orchid fragrances.

This study provides support for the proposal that euglossine orchids produce specific recipes and proportions of chemical odors to (1) increase chances of successful pollen dispersal and thus outcrossing and (2) serve as a reproductive isolating mechanism to prevent hybridization. A fragrance complex is designed to attract a limited subset of euglossines that are both effective as pollinators for that species and specialized enough that visits would not increase risk of hybridization. Further studies should be done in testing the variability of fragrance modification among chemical “types.” For instance, this study used chemicals that by themselves act as general attractants. However, modifier chemicals such as alpha-pinene may be more important to specifying the attractive ability of an orchid. The identification and
classification of orchid fragrance composition is also lacking. However, once chemicals are identified, it would be interesting to investigate the stereochemistry and test whether different isomers of chiral compounds attract different species. Finally, it would also be useful to test intraspecific variability of fragrance composition in orchids in relation to attraction of the optimal pollinator species set.

ACKNOWLEDGEMENTS

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LITERATURE CITED


TABLES AND FIGURES

TABLE 1. Abundances of male euglossine bee species visiting each chemical bait in the San Luis Valley, Monteverde, Costa Rica.

<table>
<thead>
<tr>
<th>Species</th>
<th>Cineole</th>
<th>Benzyl acetate</th>
<th>Cineole/ benzyl acetate</th>
<th>Methyl salicylate</th>
<th>Cineole/ methyl salicylate/ methyl benzoate</th>
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<tbody>
<tr>
<td><em>Eufriesea ornata</em></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td><em>Eufriesea surinamensis</em></td>
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<td>0</td>
<td>0</td>
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<tr>
<td><em>Euglossa championi</em></td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><em>Euglossa cybelia/maculilabris</em></td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Euglossa deceptrix/tridentata</em></td>
<td>2</td>
<td>11</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><em>Euglossa dodsoni/erythrochlora</em></td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td><em>Euglossa dressleri</em></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Euglossa gorgonensis</em></td>
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<td>0</td>
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<td><em>Euglossa hemichlora</em></td>
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<td>10</td>
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<td>10</td>
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<td><em>Euglossa townsendi</em></td>
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<td><em>Eulaema cingulata</em></td>
<td>0</td>
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<td><em>Eulaema meriana/bombiformis</em></td>
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<td>11</td>
<td>21</td>
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<td><em>Eulaema nigrita</em></td>
<td>0</td>
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<td><em>Exaerete frontalis</em></td>
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<td>1</td>
<td>4</td>
<td>0</td>
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</tr>
</tbody>
</table>

FIGURE 1. Total euglossine bee species richness attracted to each chemical fragrance. SE bars are shown. The letters above the bars denote significant difference in Shannon-Weiner index of the chemical. A total of 191 bees were observed, comprising 15 different species.
FIGURE 2. Euglossine bee species richness from 19.3 °C to 26.6 °C. Trials were run from 8 AM to 12 from October 27th to November 16th in the San Luis Valley, Costa Rica.

FIGURE 3. Euglossine bee abundance from 19.3 °C to 26.6 °C. Trials were run from 8 AM to 12 from October 27th to November 16th in the San Luis Valley, Costa Rica.
Corruption and Consequences: Illegal Logging in Southeast Asia

Throughout Southeast Asia, the situation today is essentially the same. A deadly combination of poorly regulated commercial logging and a thriving illegal timber trade are decimating forest resources across the region. According to the UN’s Food and Agriculture Organization, SE Asia has the highest rate of deforestation in the world (Fahn 2003). Ecological destruction of this scale has profound implications for SE Asia and the world as a whole. Indeed, the close connection between deforestation and illicit logging should be apparent as governments and NGO’s increasingly restrict, or even ban, the legitimate timber industry. This paper focuses specifically on the illegal timber trade between SE Asia and the rest of the world, namely Japan, China, the US, and the European Union. I will first examine the nature of this illicit industry and its possible consequences before moving onto the social and political forces that shape the illegal timber economy.

Significance

The sheer scope of the timber trade, both legal and illegal, warrants its continued study. While deforestation and illegal logging are popularly associated with Brazil and the Amazon, the tropical rainforests and other old growth forests found in SE Asia are in at least as precarious a position, if not more so. Take Thailand, for example. Thanks to a boom in timber exports during the second half of the 20th century, total land covered by forests fell from 50 per cent in the
1960’s to less than 25 per cent of total land by 2000 (Illegal-logging.info). A thriving illicit economy has sprung up since Thailand officially banned logging in 1989, as evidenced by the many scandals uncovered by NGO’s in the past two decades (Fahn 2003). Forests in the Philippines, which once covered almost all of the archipelago, now make up less than 20 per cent of the land (Dauvergne 1997). Indonesia faces a similar fate. Worldwide, only Brazil is losing old growth forest at a faster rate, and Indonesia is only getting worse. This is especially worrisome considering that Indonesian rainforests are the third largest in the world and the largest in Asia. Furthermore, NGO’s in the region believe that close to 70 per cent of the trees harvested in Indonesia are done so illegally (Illegal-logging.info). All exports of raw timber from Indonesia are now illegal. Deforestation is increasingly tied to illegal timber, as states face domestic pressure to stem the loss of an important natural resource.

Illicit logging in SE Asia has a number of unfortunate consequences, many of which are environmental in nature. According to the Environmental Investigation Agency (EIA), “as the forests disappear; devastating fires, landslides and floods follow, killing thousands. Illegal logging is also driving many endangered species to the brink of extinction” (“The Last Frontier” 2005). Forests help regulate the flow of water through soil, which in turn helps prevent landslides and flooding. One particularly publicized mudslide in southern Thailand during the 1980’s that killed 56 villagers was directly attributed to logging. The 1989 ban is directly connected to this not-so-natural disaster (Fahn 2003). Deforestation contributes significantly to global warming as well because forests help filter carbon dioxide out of the air. Worldwide, “deforestation accounts for approximately 20 per cent of world annual greenhouse gas emissions and is the largest source of emissions in the developing world” (Illegal-logging.info). The
environmental externalities of deforestation in SE Asia, increasingly due to illegal logging, are both acutely localized and globally relevant.

Aside from its environmental implications, this shadow economy has profound economic implications for the people of the region. First off, the forests being decimated are important to the local economies. Rural SE Asians use the forests for everything from a fuel source to air-conditioning (Fahn 2003). An estimated 50 million indigenous people live in forests threatened with destruction (Illegal-logging.info). Indeed, the poor, generally uneducated populations that live in forests or depend upon forest resources for their wellbeing are among the hardest hit by illegal logging. The livelihoods of more than one billion poverty-stricken people in the developing world are directly affected by the loss of forest resources, according to the EIA (“The Last Frontier” 2005).

Some perspectives argue that forest dwellers can benefit from the illegal timber trade by participating in it, but this naively optimistic. What control can any poor rural resident, or even some number of them, hope to exert against the billionaire “businessmen” dominating the illegal logging economy? How can they hope to benefit from an industry that is explained as such by its neighbors to the south: “It is an industry that is synonymous with political corruption, police racketeering and the brutal repression of workers, women and those who question its ways. Its operations routinely destroy the food sources, water supplies and cultural property of those same communities. They provide a breeding ground for arms smuggling, corruption and violence across the country” (Australian Conservation Foundation 2006). Clearly, forest dwellers would be better off without the illegal logging syndicates that exploit and destroy their livelihood.

Similarly, SE Asian governments are essentially robbed by the illicit timber industry in the form of lost tax revenues and depleted resources. A 2006 report by the EIA estimates that
the Indonesia government loses $4.6 billion a year to the trade of illegal timber (“Behind the Veneer” 2006). A 2007 report states that “during the first half of this decade, while Indonesia was trying to recover from the economic crisis of the 1990s, illegal logging has robbed the government of US$20 billion and an incalculable cost in terms of destroyed forests and local livelihoods” (“The Thousand Headed Snake” 2007). Combine this with the considerable funding that governments spend, at least on paper, to combat illegal logging and drain on the state grows worse. Governments are among the most negatively affected by the illegal timber trade.

The remarkable persistence of the illicit timber trade cannot be fully understood without examining who is benefitting from it as well. Aside from the consumers across the world who obtain cheaper flooring or desk furniture, the biggest beneficiaries are the so-called “Timber Barons” who run the illegal operations. The economy is dominated by predominantly foreign gangsters that keep their ill-gained fortunes in secure havens like Singapore and Switzerland. Japanese and Chinese crime syndicates and logging corporations alike use their huge financial resources to extract wealth from the region, which is in turn used to finance the web of corruption and cooptation that allows the economy to continue. The EIA states that the majority of the profit is made outside the region. Illegal merbau logs worth $120 per cubic meter in New Guinea doubled in value upon arriving in China, and would go on to be sold in the US and EU for over $2,000 once it was processed into flooring (“The Thousand Headed Snake” 2007). As expected, those actors with available capital to process the timber asymmetrically benefit from the huge value-added, leaving SE Asian governments and their law-abiding citizens with nothing.
Trade

Illicit timber in SE Asia predominantly targets tropical hardwoods like teak, balau and merbau, because they fetch higher prices in world markets. For the purposes of this paper, the focus is merbau, a dark wood that is generally regarded as an attractive and durable multipurpose timber. Merbau consists of nine species found throughout SE Asia, although the majority exists on the Indonesian island of New Guinea. (Tong P.S., Chen, H.K., Hewitt, J., and Affre A. 2009). Trade in merbau has skyrocketed in the past decade. In Papua (the Indonesian province located on New Guinea), exports of merbau increased tenfold from 1998 until the government implemented a ban on timber exports in 2001. As supply and demand would dictate, the price jumped accordingly. Given the new opportunities for profit, the volume of illegal merbau exported from New Guinea quickly passed the 2001 levels and has continued to rise, more or less unabated, according to the EIA (“The Last Frontier 2005). This is a trend throughout the region. Government restrictions on the economy only make it more attractive to those willing to break the law.

Merbau continues to be exploited for export to the rest of the world, in this case primarily China, followed by the US and the EU. The EIA points to a shift in western flooring preferences as an explanation for rising demand. As linoleum went out of fashion in the late 1990’s, hardwood floors became the new fashionable alternative. Even the market for hardwood floors is changing, from the traditional oak to the darker, more “exotic” tropical hardwoods. The EIA goes one step further here and traces the imports of individual US and EU timber corporations back to their source, which the EIA purports is almost exclusively SE Asia. According to the EIA, the vast majority of the corporations they investigated were using merbau from New Guinea, “where the vast majority of logging is illegal and where certified timber is unheard of”
(“Behind the Veneer” 2006). The illicit trade in merbau and other tropical hardwoods is fed by the insatiable demand of China and the West.

While I’m more than somewhat apprehensive about taking all of these reports and statistics from environmental NGO’s as fact, the lack of evidence to the contrary is reassuring. The Indonesia government undertook a massive operation to crack down on illegal logging in New Guinea in response to the 2005 EIA report, which lends them some credibility. Similarly, a report by the TRAFFIC organization on merbau producing regions notes that “forest inventories are lacking or obsolete in producer countries” (Tong P.S., Chen, H.K., Hewitt, J., and Affre A. 2009). This lack of forestry information has clear implications when it comes to recognizing and cracking down upon illegal logging.

**Political and Economic Constraints**

The illicit timber trade has been able to thrive in SE Asia thanks to the unique political and economic factors of the region, including widespread corruption in government and military institutions. Desperate to gain a slice of the profit, politicians, bureaucrats in forestry departments, military officers, and police struggle to sell out their nation’s natural resources most efficiently. The yearly EIA reports chronicle countless investigations into illegal logging where the culprits are powerful timber barons, “aided and abetted by corrupt police, military and government officials” (“The Thousand Headed Snake” 2007). The complicity of state actors becomes easily apparent when examining the attempted prosecution of those caught harvesting illegal timber as well. Even in cases where foreign vessels were caught with millions of dollars of unmarked timber attempting to leave Papua ports, the judicial process has failed due to bribery and powerful special interests (“The Thousand Headed Snake” 2007).
Even more extreme are the illicit logging operations that are run by the government officials themselves. For example, a 1999 investigation into illegal sawmills in Sumatra found that 13 of 25 sawmills were backed and supervised by the armed forces. Similar situations are common across Indonesia, in part because of the military’s unusual funding setup. The Indonesian military must earn 75 per cent of its annual budget from its own enterprises and funding, which are not always legal (“Above the Law” 2003). Evidence of illegal logging by government actors is apparent in 37 of 41 national parks (“The Thousand Headed Snake” 2007).

This is fairly common outside of Indonesia as well, as Fahn demonstrates. During his travels as a reporter in Thailand, Fahn learns the amazing history of Chavalit Yongchaiyudh. The Thai military general-turned-entrepreneur-turned-prime minister known aptly as “Mr. Timber” is implicated in practically every logging scandal from the mid-1980’s until the 1997 financial crisis removed his government from power. Fahn further generalizes his conclusion to say that “throughout the region, indeed throughout the developing world, guns and chainsaws seem to go hand in hand.” With the possible exception of Malaysia, he advances that the military is intimately involved in logging, usually through illegal means, in the entire region (Fahn 2003). This makes sense considering the nature of the timber economy. Timber is a highly lootable resource, which allows capital strapped military actors or their subcontractors to quickly turn trees into cash. Given the relative autonomy that central governments have historically allowed military actors in the region, especially in border areas where a large portion of forests remain, military exploitation runs rampant.

In his 2001 book examining political corruption in SE Asia, Michael Ross defines this behavior as a type of rent seeking that he coins “rent seizing.” Corruption is normally divided into two categories: rent creation and rent extraction. Rent creation refers to firms seeking to
bribe the state, whereas rent extraction conversely refers to the state trying to extort firms using the threat of regulation and fines. Rent seizing occurs when individual state actors try to access and distribute rents held in state institutions (Ross 2001). For example, forestry officials exhibit rent seizing behavior when they attempt to circumvent legal barriers in order to sell logging concessions to foreign corporations. Dauvergne alludes to a web of political patronage that he sees as the economy’s defining characteristic. The bureaucrats and politicians that receive these benefits then turn around and subcontract them to logging companies (Dauvergne 1997). Government actors who are supposed to be protecting the forests instead seek to rent it out for personal financial gain. Corruption and collusion have rendered regional governments without the capacity to deal with their domestic industry as well as foreign trade.

The nature of the region’s political regimes have also impacted the illegal timber trade, namely the general trend from authoritarianism towards democracy. Fahn revisits a study by US Political Scientist Neal Englehart that shows a direct correlation between democracy and deforestation in SE Asia. Essentially, democracy and the ensuing economic freedom enable market forces to go to work creating the most efficient possible means of exploitation (Fahn 2003). The individual concessions offered by authoritarian leaders as a means of patronage are innately inefficient at destroying the environment in this interesting application of liberal ideology. Fahn’s narrative shows another example of this trend when he reports on a border conflict between Myanmar and Thailand. The brutal SLORC junta that rules Myanmar starts a border war with Thailand in order to stop illegal logging by Thai companies across the border. It turns out that the KNPP rebels in Myanmar had been bringing Thai logging companies over the border in order to finance their war of resistance against SLORC (Fahn 2003). Similar issues came up in the 1970’s during the Khmer Rouge regime in Cambodia. Politics and the illicit
timber economy are closely linked throughout the region, due mostly to the resources lootable nature.

With so many obstacles working against them, regional governments hope that increased regional and global cooperation can help them reign in illegal logging. Regionally, nations look to continue the spirit embodied in ASEAN by synchronizing trade policy. The lack of consistency across the region has made it easy for timber traffickers, which contributed to the 2004 ASEAN Strategic Plan on Forestry. The report details the creation of a network of protected forest reserves and increased intergovernmental cooperation, but progress has been lacking (Illegal-logging.info). As it is right now, raw timber cannot be exported from Indonesia, but once smuggled into neighboring countries it is essentially fair game for many less stringent buyers in the international market. Malaysia banned the import of Indonesian Merbau in 2002 to help slow the illicit economy (Tong P.S., Chen, H.K., Hewitt, J., and Affre A. 2009). Yet until all of the regional governments agree to strengthen their policies restricting illegal timber, trade will simply flow through whichever nation has the least strict policies (or the most corrupt enforcement mechanisms).

International cooperation between the major importers and exporters of illegal timber is another option that SE Asian states are exploring. Many scholars and policy makers point towards strengthening existing agreements on illicit trafficking, like the Convention on International Trade in Endangered Species of Wild Fauna and Flaura (CITES). Timber species listed in the CITES appendix require extensive source documentation and certification in order to be traded. Currently many tropical hardwoods like merbau are not included in CITES, although Indonesia is proposing their addition. TRAFFIC explains how the CITES listing has helped in the case of the Big-Leaf Mahogany trade (Tong P.S., Chen, H.K., Hewitt, J., and Affre A. 2009).
Whether through the CITES approach or elsewhere, increased documentation and tracking of targeted hardwoods like merbau is a crucial step in stemming the flow of illegal timber.

The largest timber importers (China, Japan, the EU, and the US) need to work closely with SE Asian nations for real progress to be made however. Although Japan has traditionally had the closest ties with the SE Asian timber trade, China has rapidly become the main consumer (Dauvergne 1997). China cut all tariffs on imported timber in 1999 after they depleted their own domestic production with unsustainable logging and since then their timber imports have soared. According to the EIA, China is now the largest consumer of illegal timber in the world and has been reluctant to change thus far (“The Last Frontier” 2005). The EU and the US have been more willing to take real steps towards reducing their contribution to the problem. In 2008, the US passed an amendment to the existing Lacey Act that makes it illegal for anyone to import timber that was illegally harvested in another country into the US and places the responsibility for verifying a legal source directly on the importer (Gregg, R, and Amelia Porges. 2008). The EU is in the process of entering a Voluntary Partnership Agreement with Indonesia, which would require EU timber imports to be certified as legally harvested (Illegal-logging.info). This sort of bilateral cooperation between the primary state actors in the illicit timber economy should have a significant effect if the measures are fully enforced.

**Conclusions**

Its success owed to a combination of widespread corruption at the local level and intense international demand, the illegal timber trade in SE Asia continues a dangerous trend of deforestation and political patronage that will adversely affect the region for decades to come. Possible solutions abound in the form of regional and international cooperation, but without some semblance of just enforcement from SE Asian states no real improvement is in sight as
long as demand stays high. Perhaps NGO’s like the EIA and TRAFFIC should be shifting their efforts towards educating consumers on what their new merbau floor really costs instead of pressuring governments that have shown an inability to make real progress. Until then, a region once described as “the closest place to the Garden of Eden as you’re going to find on Earth” will continue to be exploited and destroyed.
Bibliography


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