Descriptions of Javan gibbon social organization usually emphasize the small group size, territoriality, and monogamous mating pattern. However, there are relatively few data on the distribution, behavior, or socioecology of this species (Kappeler, 1984; Nijman, 2001). These data are important for the conservation of this species, as well as for developing accurate evolutionary models of gibbon social systems.

In an attempt to continue to develop an effective conservation action plan for the protection and management of the silvery gibbon of Java, we observed a small population of silvery gibbons in the Cagar Alam Leuweung Sancang (CALS), West Java, Indonesia. The objectives of this research were to:

1) Describe the current ecological conditions of CALS in general, and of the gibbon population in specific, based on an overall survey of the reserve and systematic observations of focal groups including both visual and auditory observational methodologies; and 2) Contextualize the results of this research within current frameworks for understanding the evolution of social systems in the Hylobatidae, test ecological predictions, and assess the viability and adaptability of the CALS population given the history of deforestation and continued use of gibbon habitat by humans.

**METHODS:**

The 2,157 hectare Cagar Alam Leuweung Sancang (CALS), located on the south coast of West Java (Kabupaten Garut; Figure 1), was established to protect the lowland dipterocarp and mangrove forests, as well as a multitude of either endangered or endemic Javanese species of flora and fauna. Despite this official protection, approximately half of the forest within the reserve boundaries has been lost due to large-scale, illegal timber extraction culminating with the rapid deforestation and sale of timber in 2000-2001. A 2003 operation to displace these illegal gardens was largely successful (Kepala BKSDA Jabar II: Ciamis, personal communication). However, as recently as August 2005, evidence of small-scale, illegal extraction of both valuable trees (timber) and non-timber forest products continues within the reserve boundaries (Figure 2).

CALS is home to the largest lowland population of the critically endangered silvery gibbon of Java (*Hylobates moloch*) outside of Ujung Kulon National Park. An extensive survey of the reserve in 1995 reported an estimated population of between 30-42 individuals in ten groups, and a density estimate of 0.56 groups/km² (Megantara, 1995). In 2002, the population dropped to between 18-24 individuals in 8 groups. With the loss of 35.9% of the forested area within the reserve since 1995, the density estimate following the 2002 census effort reveals a significant increase to 1.99 groups/km² (Pakpahan, 2003).

The current research focused on three focal groups in a fragmented and disturbed area of the reserve. This riparian forest was characterized as an open-canopy, primary deciduous forest with a closed under-story. The steep slopes and history of human alteration (i.e., construction of a cement walkway including steps), combined with the range-limiting implications of past logging activity provided for unusually high observational quality with only limited habituation of the animals.

We recorded daily temperature and rainfall, and assessed soil quality (i.e, pH and levels of nitrogen, phosphorous, and potash) monthly. We also assessed vegetation quality, by taking the following measurements of trees in four 0.1 ha belt transects: diameter of trees at breast height (DBH), height, canopy size/shape, monthly observations for the presence of flowers, fruit, or new leaves.

Behavioral data were collected from three neighboring groups of Javan gibbons in the study area. For each observation day (n=46) we attempted to make visual and audio contact with the focal groups. First-contacts would automatically begin a full-day follow of that group and systematic data collection using focal-animal scan sampling (Altmann, 1974). At two-minute intervals, the behavioral state for each individual in the focal group was determined and recorded in one of six non-overlapping behavioral...
categories. Further, the timing of all approaches and withdrawals by individuals to within three meters and within one meter of another individual were recorded. All-occurrences of social behaviors such as grooming, copulations, or inter-group encounters were recorded.

The human use of the study area was monitored by counting the number of people accessing the forest each day and describing the activities that were pursued. Specifically, behaviors that directly or indirectly impacted the ecology of the reserve or the behavior of the gibbon groups were noted.

**Figure 1.** The location of the Cagar Alam Leuweung Sancang (CALS) in West Java and a detail of the major geographical features within the reserve boundary.

**PRELIMINARY RESULTS**

Temperatures ranged between a 20.2°C and 36.5°C. The total rainfall for the same period was 121.54 cm. These periods corresponded with a large fruit crop of Dracantomelon, a preferred food of gibbons. There were only small differences in the species richness and density of important tree species between the core and edge habitat types. Average DBH is larger in both the core samples, perhaps reflecting the differential access to the selective removal of valuable, old-growth trees, but also potentially indicative of a difference in productivity.

While the majority of behavioral data have yet to be analyzed, some trends were obtained. Gibbons were active for an average of 11:30 hours per day. They spent an average of 13:05 in at rest in their sleeping trees. Territory size was determined by the location of song-bouts, inter-group encounters, and the analysis of aerial photos to determine habitat parameters. Territory size of the three groups ranged from 6.25 ha to 15 ha, below the reported average of 17 ha for the species (Kappeler, 1981, 1984).

An average of 16.73 people per day (n=41 days of observation) engaged in activities within the gibbon territories.

**Figure 2.** August 2005: An example of continued, small-scale extraction of wood from within the reserve boundaries.

**SUMMARY OF CONSERVATION ACCOMPLISHMENTS**

The contemporary and historical patterns of human influence at this study site provide a unique context in which to systematically assess the impact of anthropogenic disturbance on primate social systems. Specifically, the demographics of the study population, as well as the effects of deforestation on ranging behavior and habitat quality, create suitable conditions for the testing of ecological hypotheses for the evolution of small group size, territoriality, and mating patterns within the Hylobatidae. Further, one of these hypotheses, infanticide avoidance, has been posited as a primate-wide, ultimate explanation for permanent associations between males and females. However, the preliminary analysis of this data set reveals patterns of male-male and male-female cooperation in defense of resources, rather than inter- and intra-sexual conflict over access to mates. The behavioral profiles, discerned from focal group scan data and proximity maintenance data indicate stable social relations between both adult males and the adult female (and physiologically dependent infants). These insights into evolutionary strategies, made evident within the context of anthropogenic disturbance, would not have been possible without the interdisciplinary and holistic approach of this research.

At this point in the analysis two implications, vital to the conservation strategy for Javan gibbons, are discernible. First, the overall population size for Javan gibbons has been calculated previously by extrapolating from estimates of average individual density to the amount of remaining habitat. However, this study reports substantial variability in home range size, individual density, and the actual presence/absence of gibbons in suitable habitat. Therefore, the need for an accurate, species-wide population assessment, based on ground truth data and patterns of human extraction throughout the range of the Javan gibbon, is recommended. Second, in previous calculations of population viability, the effective population size for gibbons (number of individuals with reproductive capabilities) has been directly equated to the number of mature adults. This equation is based on assumptions of a species-typical monogamous mating pattern, with very little consideration of polygyny-skew effects. However, if some males are realizing a genetic result from extra-pair copulations or membership in greater than two adult groups, other males may be contributing little in the way of genetic input to future generations. Therefore, in population viability models, effective population size may not directly equate with the number of mature adults, and subsequently increase the minimum number of individuals required to constitute a viable population.

Finally, the project has served as a catalyst for increased communication and cooperation between the government-employed forestry police and the residents of the Sancang Village. A renewed effort of cooperation and collaboration, especially in regard to the reporting of illegal activities (i.e., timber extraction and hunting) and the monitoring of human activities (including tourist visits and religious practices), has begun in earnest. The collection of visitor fees and an increased research presence is building the foundations for long-term monitoring and educational programs.

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