Abundance, Distribution, and Reproductive Success of Sandbar Nesting Birds Below the Yali Falls Hydropower Dam on the Sesan River, Northeastern Cambodia

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PROJECT SUMMARY

River ecosystems in Southeast Asia are some of the most biodiverse, yet most highly threatened in the world. Northeastern Cambodia supports numerous bird species of conservation significance, many of which depend on the river systems for all of their habitat and food requirements. The contiguous stretches of the Mekong River and its three major tributaries, the Sesan, Sekong, and Srepok Rivers, have immense regional importance for riverine birds. Several species of riverine birds nest on sandbars, which makes them particularly vulnerable to alteration of the river habitat, predation, and disturbance.

We conducted surveys and nest monitoring on the Sesan and Sekong Rivers from 21st February through 6th May 2003. Focal bird species included the sandbar nesting black-bellied tern (*Sterna acuticauda*), river tern (*Sterna aurantia*), river lapwing (*Vanellus duvaucelii*), great thick-knee (*Esacus recurvirostris*), small pratincole (*Glareola lactea*), and little ringed plover (*Charadrius dubius*), and the Mekong wagtail (*Motacilla samveasnae*) which prefers rocky rapids.

The Sesan River, our primary study area, had extensive sandbar habitat, while the Sekong River, our comparison study area, had less sandbar habitat and more areas of channel mosaic and rocky rapids. The Yali Falls dam is situated on the Sesan River in Vietnam about 70 km from the Cambodia/Vietnam border. Although the Yali Falls dam did not become fully operational until 2001, it has caused unnatural daily fluctuations in water level during the dry season since 1996. The Sekong River has not been noticeably affected by dry season water fluctuations.

Major threats to sandbar nesting birds on the Sesan River are inundations of nests and chicks, reduction in breeding and foraging habitat, and reduction in food sources caused by the Yali Falls dam, predation of nests and chicks by animals, egg collection by villagers, and incidental disturbance by villagers and domestic animals.

Numbers of river lapwings and small pratincoles were significantly lower than counts conducted in 1998. Dam-related inundation and predation caused an equal number of nest failures of all focal bird species combined, however predation levels may have been augmented by the decreased area of sandbar habitat when water levels were high due to large releases of water from the Yali Falls dam. Egg collection by villagers was the next highest cause of nest failure of all focal species combined.

In order to minimize the negative effects to sandbar nesting birds, the flow regime of the Yali Falls dam should be operated to replicate the natural daily and seasonal flow cycle of the Sesan River. No large peak releases of water should occur during the breeding season (February through May) of sandbar nesting birds. Strong mitigation measures to reduce the negative impacts of the Yali Falls dam need to be implemented. Further research needs to be conducted on the impacts of hydropower projects on river geomorphology, fish populations, and water quality of the Sesan River. Further meetings with all villages located along the Sesan River should be held to raise awareness about the conservation of sandbar nesting birds.

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INTRODUCTION

Southeast Asia contains some of the most biodiverse, yet most imperiled riverine ecosystems in the world (Dudgeon 2000). Large rivers are one of the least understood ecosystems (Brockelman 2002), and their linear shape and cross-boundary nature makes it difficult to afford them with adequate protection (Timmins and Khounboline 1996, Duckworth *et al.* 2002). Riverine habitats support a wide variety of bird species, many of which nest on sandbars, or otherwise specialize in river channel habitats. Recent studies in Thailand (Lekagul and Round 1991), northern Laos (Duckworth *et al.* 2002), southern Laos (Duckworth *et al.* 1998, Thewlis *et al.* 1998) and northeastern Cambodia (Timmins and Men Soriyun 1998, Van Zalinge *et al.* 2002) have suggested that riverine bird populations are declining throughout mainland Southeast Asia, with numbers of many species being much greater historically.

In northeastern Cambodia, the contiguous stretches of the Mekong River and three major tributaries, the Sesan, Sekong, and Srepok Rivers, have been identified as having high conservation significance for riverine birds, especially for resident waders and other shorebirds (Mundkur *et al.* 1995, Timmins and Men Soriyun 1998, Van Zalinge *et al.* 2002, Timmins *et al*. 2003, Seng Kim Hout *et al*. 2003). Past surveyors (Mundkur *et al.* 1995, Timmins and Men Soriyun 1998, Van Zalinge *et al.* 2002), having limited time, have focused on getting broad perspectives of birds in the region and have collected baseline information on distribution and abundance. However, there is a shortage of breeding information on riverine birds in the Mekong River Basin.

"Population sinks", which occur in poor quality habitats where birds are present in high densities but have low productivity, cannot be determined using estimates of bird densities alone. Although factors such as food availability, age distribution, survivorship, site fidelity, and dispersal rates can influence source-sink population dynamics, it is essential to determine reproductive success as a measure of productivity when evaluating whether or not the habitat supports a "population source" (Pulliam 1988). Investigating reproductive success levels and what influences them, can give us a better understanding of the mechanisms underlying population decline, which is imperative if population concerns are to be addressed and recommendations are to be made.

The Sesan River in northeastern Cambodia has high regional importance for internationally significant riverine bird species such as river lapwing (*Vanellus duvaucelii*), great thick-knee (*Esacus recurvirostris*), river tern (*Sterna aurantia*), small pratincole *(Glareola lactea*), and the globally near-threatened black-bellied tern (*Sterna acuticauda*) (Mundkur *et al.* 1995, Timmins and Men Soriyun 1998), all of which nest on sandbars.

Species that nest on sand and gravel bars are particularly vulnerable to breeding season disturbances, due to higher levels of human activity on sandbars (Duckworth *et al.* 1998, Timmins and Men Soriyun 1998). Collection of eggs by humans has been documented in Laos (Thewlis *et al.* 1998, Duckworth *et al.* 1999, Cunningham 2001). On the Sesan River, Timmins and Men Soriyun (1998) documented a single villager searching for a river tern nest. Timmins and Men Soriyun (1998) speculated that poor breeding success, caused by egg collection and incidental disturbance by humans and domestic animals, was the reason they observed few juveniles during sandbar surveys on the Sesan River.

However, at the time of their surveys, Timmins and Men Soriyun (1998) were unaware of the existence upriver of the Yali Falls dam in the Central Highlands of Vietnam (R.J. Timmins pers. comm. 2002). The 720MW Yali Falls Dam, which began construction in 1993 and became fully operational in 2001, is situated on the Sesan River about 70km from the Cambodian border (Fisheries Office and NTFP, 2000). Hydropower development is a major threat to riverine ecosystems in Southeast Asia, due to alterations of natural hydrological patterns causing decreased habitat quality for wildlife, including riverine birds, and decreased biodiversity overall (Duckworth *et al.* 1998, 2001, Dudgeon 2000, Davidson *et al.* 2001, Round 2002).

In Cambodia, the rainy season typically ends in November, and water levels continue to drop until the rains recommence in May. However, the release pattern from the Yali Falls dam during the dry season is one of variable flows, with daily water level fluctuations of up to one or more meters (Ratanakiri Water Resources and Meteorology Office, raw data from January–May 2003).

During the breeding season, sandbar nesting species are highly susceptible to unnatural changes in water level caused by water releases from dams. Water fluctuations caused by dams have negatively impacted least tern (*Sterna antillarum*), piping plover (*Charadrius melodus*), and Canada goose (*Branta canadensis*) populations in the United States by flooding nests and chicks, limiting food availability, and altering nesting habitat (Casey *et al.* 1985, McDonald and Sidle 1992, Schwalbach *et al.* 1993, Tibbs and Galat 1998).

Although high water flows are occasionally necessary to scour sandbar vegetation, build up existing sandbars, and create new sandbars, extended high flows, and varying daily flows decrease the area of available nesting and foraging habitat when water levels are high (Sidle *et al.* 1992, Leslie *et al.* 2000). As well as reducing the areas available for breeding and foraging, habitat loss can further decrease the proportion of chicks that successfully fledge (Espie *et al.* 1998). Sandbar erosion coupled with the lack of newly created sandbars leads to more severe habitat loss for sandbar-nesting species (Ligon *et al.* 1995, Stevens *et al.* 1997). This results from sediment being trapped in reservoirs, which starves the river of its sediment load and creates a "hungry water" effect downriver, by which the river regains its lost sediment through erosion of its bed and banks. The effect of large dams on the river channel will ultimately be to convert wide, braided channels with many sandbars into deep, narrow, featureless channels (McCully 1996).

The construction of the Yali Falls dam has heavily impacted all 90 villages situated along the Sesan River in Ratanakiri and Stung Treng provinces right up to its confluence with the Mekong River. Dam related floods have caused at least 32 people and numerous domestic animals to drown, destroyed rice paddies and riverbank gardens, and washed away boats and fishing gear. Villagers have experienced increases in stomach illnesses from drinking river water, skin rashes from bathing in the river, and have also reported that the dam has negatively impacted fish and other wildlife populations, including various species of riverine birds (Fisheries Office and NTFP 2000, Baird *et al.* 2002).

Dams limit fish migration and alter fish breeding habitat and breeding cycles, which can lead to population reductions (Ligon *et al.* 1995, Dudgeon 2000). Low flows coupled with high temperatures can also directly cause fish die-offs (Kirsh and Lingle 1993, Lingle 1993). There have been dramatic declines in fish populations on the Sesan River since construction of the Yali Falls dam began (Fisheries Office and NTFP 2000, Baird *et al.* 2002). Villagers

who we interviewed reported that fish catches are only a tenth of what they were before the dam. Some of the fish die-offs may be due to water temperature increases caused by Yali Falls dam operations (CRES 2001). Dam-related reductions in fish species such as *Henicoryhnchus lobatus* (Trey Riel in Khmer) may have reduced prey for fish-eating birds (I.G. Baird pers. comm. 2003). Fish are the major food source for river terns and black-bellied terns, as well as herons, egrets, kingfishers, and fish-eagles. High flows and fluctuating flows can also reduce the amount of foraging habitat for fish-eating birds (Tibbs and Galat 1997).

Reportedly, there has been a decrease in certain insect and arthropod (including freshwater shrimp) populations on the Sesan River (Fisheries Office and NTFP 2000, Baird *et al.* 2002). Fluctuating flows can cause direct die-offs of sand-dwelling invertebrates, which are unable to retreat quickly enough when the water level rises. Erosion below dams reduces gravel and other sediment, which is important habitat for aquatic invertebrates (McCully 1996). Also, altering the flow regime reduces the oxygen content and nutrient levels of the river (Brockelman 2002), and together with the increased river turbidity, contributes to decreased amounts of algae (Fisheries Office and NTFP 2000, Baird *et al.* 2002). Algae are an important food source for fish and aquatic invertebrates. These invertebrates are in turn the major food source for river lapwing, small pratincole, little ringed plover, Mekong wagtail, and migratory shorebirds.

Objectives

The primary objectives of this study were to gather information about the breeding behavior, breeding habitat criteria, nest site selection, and nesting success of seven focal sandbar nesting bird species (Table 1), providing insight into productivity levels, and whether low reproductive success has contributed to the decline of sandbar nesting bird populations on the Sesan River. We investigated whether, and to what extent, hydrological changes caused by the Yali Falls dam may have affected sandbar nesting bird populations on the Sesan River. We investigated the influences of dam-related inundation, egg collection, predation, and incidental disturbance on the reproductive success of the focal species. We held discussions and interviews with villagers living along the Sesan River to gain further historical and regional perspective on the current state of riverine bird communities, and worked with three villages (Phum Hat Pok, Phum Voen Hoy, and Phum Lumphat) to protect black-bellied tern nesting sites.

Focal Bird Species

Table 1: Names and Status of Focal Bird Species on the Sesan and Sekong Rivers.

English Name	Latin Name	Status	Khmer Name	Lao Name
River Lapwing	*Vanellus duvaucelii*	ARL	Trodea Wit Tonle	Nok Komah
River Tern	*Sterna aurantia*	ARL	Rompei Tonle	Nok Sida
Black-bellied Tern	*Sterna acuticauda*	GT-VU	Rompei Phua Khamao	Nok Oumpham
Great Thick-knee	*Esacus recurvirostris*	ARL	N/A	Nok Mouam
Small Pratincole	*Glareola lactea*	PARL	N/A	Nok Khao Sai
Little Ringed Plover	*Charadrius dubius*	N/A	N/A	Nok Khao Sai

GT-VU = Globally Threatened-Vulnerable, ARL = At Risk in Laos, PARL = Potentially At Risk in Laos. Species status and status categories for Cambodia have not yet been designated; therefore regional status in Laos (Duckworth *et al.* 1999) has been used. For the purposes of this study it is assumed that birds in Laos face similar threats to birds in Cambodia. Although little ringed plover has not been listed as having a special status, it faces many of the same threats as the other sandbar nesting species, so has been included as a focal species for this study. Mekong wagtail is a newly described species (Davidson *et al.* 2001, Duckworth *et al.* 2001). Although it does not nest on sandbars, it is a riverine specialist, so also faces many of the same threats as sandbar nesting species and has been included as a focal species.

Lao names are those given to us by villagers, after discussion of similar species to avoid confusion, and in conjunction with Cunningham (2001). Lao is widely spoken along the Sesan River, and using the Lao names of focal species proved especially useful during discussions with villagers. Many people in Khmer villages, as well as villages of other ethnic groups, also knew the Lao names of birds. Khmer names of river lapwing and river tern are those listed by Sun Hean *et al*. (1998) and were familiar to villagers on the Sesan River. Although villagers along the Sesan River were familiar with the differences between larger species, smaller species such as small pratincole and little ringed plover were not differentiated by local people and were treated as the same species. Hence the Lao name for small pratincole and little ringed plover are the same. Even after showing drawings and photographs and describing differences in the appearance and behavior of the two species, villagers often did not recognize the differences between the two species.

STUDY AREA AND METHODS

Study Area

The primary study area covers the Sesan River in Ratanakiri and Stung Treng provinces in northeast Cambodia (figures 3 and 4). The Sesan River originates in mountainous central Vietnam, before entering the rolling hills and lowlands of northeast Cambodia. The width of the Sesan River ranges from about 75 m in O Yadao district, near the Vietnam border, to about 250 m further downriver. The Sesan River is one of the largest tributaries of the Mekong River. In Stung Treng province, the Sesan River is joined by the Srepok River, and then the Sesan River joins the Sekong River, which finally runs into the Mekong River at Stung Treng town. The Sesan River is largely comprised of many large sand and gravel bars and islands, some of which are partly vegetated. We will henceforth use the term "sandbar" to refer to all sand or gravel bars and islands. The Sesan River also contains some long, single channel stretches that are devoid of sandbars, and a few short sections of rocky rapids. We surveyed a distance of about 198 km on the Sesan River. The surveyed section was from Phum Phi in O Yadao district, Ratanakiri province to about 3 km downriver of Phum Khsach Thmei (locals usually refer to this village by its Lao name, Sai Samee), in Sesan district, Stung Treng province. The human population living along the Sesan River is about 50,000 people from 90 villages and comprised of at least twelve ethnic groups (Khmer, Khmer Khe, Lao, Lao Deum, Chinese, Brao, Kreung, Lun, Tampuan, Jarai, Kavet, and Kachok) (Fisheries Office and NTFP 2000, Patterson 2000, Baird *et al.* 2001).

Survey results from the Sesan River (Figure 3) were compared to those from the Sekong River in Stung Treng province (Figures 4). The Sekong River originates in the Annamite

Mountains of central Vietnam, before flowing through southern Lao PDR and entering northeast Cambodia. The 150 MW Houay Ho dam is situated on a tributary of the Sekong River in Champassak province Laos (TERRA 1997-1998). However, the Sekong River has not experienced noticeable water fluctuations during the dry season, such as those occurring on the Sesan River due to the Yali Falls dam (Baird *et al.* 2002). The Sekong River has a much higher proportion of channel mosaic and rocky shrubland than the Sesan River, with sand and gravel bars being much less extensive. The surveyed section of the Sekong River was from Siem Pang to Stung Treng town, a distance of about 86.5 km. The human population is much lower on the Sekong River than on the Sesan River. There are only 18 villages on the surveyed stretch of the Sekong River, most of which are located near the district center of Siem Pang.

Surveys

Fieldwork was conducted from 21st February through 6th May of 2003, during the late dry season. This time period coincided with the peak breeding season for the focal bird species (Table 7). Two surveys were carried out on both the Sesan and Sekong Rivers, one near the beginning of the field season (henceforth called survey 1), and one near the end (henceforth called survey 2) (Tables 4 and 5). On the Sesan River, observation effort was approximately 45 hours for survey 1, and 40 hours for survey 2. On the Sekong River, observation effort was approximately 10 hours for each survey. Surveys were conducted by long-tailed motor boats moving slowly along the river. All sandbars that had areas not entirely visible by boat were stopped at and investigated on foot. Stops were also made at many smaller sandbars so as not to miss more cryptic species, such as small pratincole, or shyer species, such as great thick-knee, which can be easily missed when conducting surveys solely by boat (Timmins and Men Soriyun 1998, Duckworth *et al.* 2002). By stopping often and walking all large sandbars, accurate and complete counts of sandbar nesting birds were obtained. Surveys were conducted throughout the day. Although the time of day and breeding stage affects the detectability of particular species, the high level of coverage of the sandbars compensated for this.

Habitat Characteristics

During boat surveys, habitat characteristics were also measured. The following parameters were recorded for each sandbar encountered: location (UTM coordinates), type (right mainland, left mainland, island), length, width, and percent composition (sand, gravel, rock, woody vegetation, herbaceous vegetation, grass).

Species List

A list of all bird species recorded during the field season was maintained (Table 9) and an index of relative abundance of observations of riverine species was used. A species was recorded as “common” if it was observed by several individuals per day, “occasional” if it was observed by at least one individual per one to two days, and “rare” if it was observed by fewer than one individual per one to two days. Non-riverine species observed were recorded as “present”, since all observations of non-riverine species were incidental.

Breeding Behavior

All observations of breeding behavior of key species including territorial behavior, defensive behavior, distraction displays, and parent roles were recorded. The sensitivity levels of incubating birds to investigator disturbance were also recorded. When approaching a nest, the distance to the nest before the parent bird was flushed was recorded, as well as the distance flushed. When departing from a nest, the amount of time that passed before the parent bird returned to the nest was recorded.

Nest Searching and Monitoring

Nest searching was conducted between Phum Bo Kham in Andong Meas district, Ratanakiri province, and Phum Khsach Thmei in Sesan district, Stung Treng province. Initially, work focused on areas between Ta Veng and Phum Lumphat (residents call it Phum Bat Lao) near the Stung Treng/Ratanakiri border, but since nesting birds were widely distributed along the river, and nesting was not especially synchronous between key species (pers. obs.), it was found necessary to expand the boundaries to find nests wherever possible along the whole surveyed stretch of river.

When a pair of birds or a single bird exhibiting territorial or breeding behavior was sighted, it was observed for usually 15 minutes to one hour. Observation continued until the nest had been located, it appeared that the birds did not currently have a nest, the nest had not been located after an hour or more of observation, or a high level of disturbance to the birds had been created for 10 to 20 minutes (10 minutes when temperatures were high, 20 minutes when temperatures were relatively low). In a few areas with high concentrations of small pratincole, transects were walked systematically, searching for nests out in the open and under vegetation. This was only conducted when it was relatively cool, and would continue for up to about 20 minutes.

Upon locating a nest, UTM coordinates were recorded using a Garmin etrex Legend GPS and marked it by pushing small sticks into the ground 5 m to the east and west. Nest monitoring frequency was generally every one and a half to two weeks.

In order to estimate incubation stage, and thus more accurately determine nest fate given the large length of time between nest checks, it was found necessary to float eggs. Float depth and angle can be used to determine the incubation stage of eggs (Westerkov 1950, Hays and LeCroy 1971) and does not reduce hatchability of the eggs (Alberico 1995). One egg from the nest was gently placed in a cup of water for less than five seconds before being returned to the nest in its original position.

During each visit to a nest site the number of eggs, float depth and angle of the eggs, parent behavior, and the number and type of possible predators and disturbance factors per observation period was recorded. Nest site characteristics such as distance of the nest to the nearest river channel, estimated height of the nest above the nearest river channel, estimated width of the river channel, and estimated length, width, and composition of the sandbar were recorded. The distance of the nest to the high water mark was also measured, as evidenced by scouring, wet soil, and debris deposition (Casey *et al.* 1985).

Nest fate determination was based on a combination of factors including the estimated age of the nest, parent behavior, size and shape of shell fragments (Green *et al.* 1987, Mabee 1997), feces at the nest, high water mark, and human and animal tracks in the vicinity.

River Turbidity

To measure relative river turbidity a yellow plastic disk 20 cm in diameter attached to a pole was used. Usually, water turbidity disks are measured at the point where they completely disappear when lowered into the water. However, due to the shallowness of the Sesan River, the disk was lowered until its outline was no longer visible, and then this distance was measured to obtain relative turbidity. Relative river turbidity was recorded at approximately 10 km intervals during survey 2 of the Sesan and Sekong Rivers. Relative river turbidity was also ecorded whenever a river tern was observed fishing in the Sesan River. River terns were not observed fishing on the Sekong River.

Non-Focal Species

Any relevant observations of non-focal bird species were recorded, noting date and details of behavior and location (Table 10). Relevant observations of mammals were also recorded, such as long-tailed macaques (*Macaca fascicularis*) and otter species.

Village Presentations and Interviews

Rriver bird awareness presentations and interviews were conducted in 10 villages along the Sesan River in Ratanakiri Province, and at three workshops held by Sesan Protection Network (SPN) attended by focal people, elders committee members, and village chiefs from roughly 25 villages along the Sesan River. During presentations, the project was introduced, information was provided about river bird communities and the importance of bird conservation, interview questions were asked, and discussions into ways to minimize human disturbance to sandbar nesting species were held. Through interviews a greater historical and regional perspective of the distribution and abundance of focal species was gained. Information about the amount and types of hunting and egg collection practices engaged in by villagers was also obtained.

In addition to formal presentations and interviews, many informal interviews were conducted with villagers opportunistically. Efforts were made to increase the effectiveness of informal interviews by interviewing small group of villagers, eliminating some of the chaos of large group interviews, while ensuring that answers were somewhat "peer reviewed". Middle-aged villagers, aged 30 to 50, were targeted as they are old enough to have experienced the many changes of the river and its biota over years, but are still young enough to be actively utilizing the river and its resources (Baird, 2003).

Village Protection of Black-bellied Terns

On 11-12 April we met with three villages: Phum Hat Pok and Phum Voen Hoy, which are Lao villages, and Phum Lumphat, which is a Kreung village. All meetings were held in the Lao language. The ultimate purpose of the meetings was to specifically discuss strategies for protecting black-bellied tern nesting areas.

Statistical Analyses

All statistical tests comparing bird densities were performed, using bird counts from both surveys 1 and 2 of the Sesan and Sekong Rivers. However, in most cases, the statistical significance was the same regardless of which count was used. In these cases, the results of

the highest count obtained for each species was reprorted, thereby reducing confusion in the RESULTS section. All descriptive statistics - paired *t*-tests, independent *t*-tests, and one-way analysis of variance (ANOVA) - were performed using STATDISK V 8.1. All Spearman's rank correlations were performed using SYSTAT 10. The level of significance for all statistical tests was set at $P < 0.05$, to minimize type I errors.

RESULTS

Breeding Behavior

River Lapwing (Vanellus duvaucelii)

Much more time was initially observing and searching for nests of river lapwings than the other focal species, because river lapwings are territorial and very visible (pers. obs., Duckworth *et al.* 1998). However, few river lapwing nests were actually located. Likely reasons for this are that either many pairs were not breeding, or had very early nests that were not located. Early in the season many agitated river lapwings were encountered, but few nests and no chicks were observed. It was later discovered that river lapwings are generally fairly silent while nesting, not becoming very agitated or vocal until their eggs have hatched.

During the incubation stage one parent, presumably the male, spent most of its time guarding the territory at the water's edge, while the other parent, presumable the female, spent most of her time tending the nest. When investigators approached within 50 – 100 m, females tended to stealthily depart from the nest to about 50 m away and wait, motionless, with body in a horizontal position, until investigators departed from the area. Parents usually returned to the nest within 1 - 5 minutes. The guarding male's behavior included alarm calls (though usually only a few), stretching its body upwards while raising its crown, lowering its body into a horizontal position, or repeatedly "kneeling" and standing up again. Males relieved the females of their incubation duties periodically, but usually for only a short time. Females often foraged for a short period before returning to the nest. Although females seemed to spend less time guarding the territory than males, both parents defended the territory when potential predators approached too closely. While on the nest, females generally seemed to sit lower and be stealthier when moving to and from the nest than did the males.

At separate locations on 10th March, 12th March, and 7th April, young (possibly a few days to a week old) river lapwing chicks were observed foraging with adults. When investigators approached within 200 - 300 m, both parents became very agitated and began calling loudly and continuously while flying in circles around the intruders. On several occasions river lapwings presumed to have chicks were observed chasing large-billed crows (*Corvus macrorhynchos*). At Kaoh Romleung Island near Phum Voen Hoy, a pair was observed repeatedly diving at a great thick-knee.

Chicks were not observed at any site on visits subsequent to initial sightings. On subsequent visits to sites where chicks had been sighted, (presumed) female river lapwings were observed near dense vegetation, while (presumed) males remained about 100 – 200 m away guarding the territory. When investigators approached within 200 - 300 m both parents started to call loudly and continuously. The males flew around, and sometimes ran towards investigators with lowered body. Within about 100 m, the females ran or flew away, calling loudly throughout. Although many pairs of river lapwings exhibited similar behavior, a few of which were known to have successfully hatched chicks, no chicks were observed (even after close examination of vegetation). It is possible that there were chicks nearby in these

instances, which were hidden extremely well in the vegetation. On at least six occasions, adults were observed that had been agitated, near vegetation. In these instances, even after continued observation for up to two hours at a distance of 200 m, no chicks were sighted.

In early April, groups of three to six river lapwings began to be sighted together on sandbars. All of the individuals in these groups appeared to be in adult plumage. Timmins and Men Soriyun (1998) also reported that most of the birds they sighted appeared to be adults, but that it did not seem likely that they had overlooked young birds. The reason for this being unlikely was not explained. The author concludes that some of the birds observed may actually have been fledged young, but that at a distance they appeared identical to adults. All of the birds in these groups became very agitated and took flight when approached within 200 - 300 m, making it difficult to get close enough to observe subtle juvenile characteristics.

River Tern (Sterna aurantia) and Black-bellied Tern (Sterna acuticauda)

River terns and black-bellied terns exhibited very similar behavior while incubating. Both species aggressively defended their nests by diving at large-billed crows, river lapwings, great thick-knees, and members of the research team. Black-bellied terns defended their nests even more aggressively than river terns. Black-bellied terns were often observed attacking or chasing river terns that approached too close to their nests. Both species were observed collecting river water to cool down their eggs by flying down and dipping their bellies in the river, then returning to their nests. When temperatures were high, this activity was repeated about every 10 minutes. Both sexes of river terns shared the role of incubating. It was unclear whether Black-bellied terns shared incubation duties between sexes. Both river terns and black-bellied terns spent considerable amount of time away from their nests, which made it difficult to tell which bird was returning to the nest.

Villagers living along the Sesan River reported that in the past (before the last 5-10 years), river tern colonies of three to five pairs were very common, colonies of 10 - 20 pairs were not uncommon, and that on occasion they have seen up to 50 pairs in a single location. On the Sekong River, a colony of 10 pairs was observed nesting on a single large island (Kaoh Tbeng). The shortest distance between two river tern nests was about 30 m, with the other nests more spread out with distances of about 150 – 300 m between them. However, during surveys on the Sesan River, more than one nesting pair was observed at only a few locations. Two pairs were consistently present at Kaoh Romleung Island, although on 11 April, three pairs were observed there. Two islands upriver of Voen Sai housed had two pairs each. One mainland sandbar downriver of Phum Talat also supported two pairs.

Small Pratincole (Glareola lactea)

The observed behavior of nesting Small Pratincole included gaping, broken wing displays, and attempts to lure intruders away by settling on false nests. Because they are colony nesters, they were more sensitive to disturbances near the nesting areas. Even when investigators or other disturbance factors were at a distance of 300 m or more from the colony, the birds became agitated. Once one bird became agitated, the agitation would tend to spread throughout the whole colony, with many taking flight while calling profusely. Even after investigators departed, it often took small pratincoles up to about 20 minutes to settle down and return to their nests.

Young small pratincole chicks were well hidden, crouching motionless under vegetation, driftwood or other objects where their cryptic coloring made them very difficult to spot. By the time they molted into their juvenile plumage, they were able to run very quickly. At this

point they sat out in the open with the adults and were much more easily observed and counted.

Little Ringed Plover (Charadrius dubius)

The observed behavior of nesting little ringed plovers included alarm calling, tail bobbing, broken wing displays, settling on false nests, and wading breast-deep into water and then nervously moving back and forth. Usually one little ringed plover (presumable the female) spent most of its time tending the nest. The other parent (presumably the male) spent most of its time guarding the territory and foraging at the water's edge. The guarding parent shared incubation duties on occasion in order to let the other parent forage. Little ringed plovers returned to the nest more quickly than the other focal species after investigators departed from the area. Usually individuals began moving back to their nests even while investigators were still moving away, and were back on the nest within about 30 seconds. When an adult departed from or returned to the nest it was in a low, silent run. When returning, they often overshot the nest, paused to make sure the danger had completely passed, and then backtracked to the nest.

After chicks had hatched, they were fairly visible, foraging out in the open with one or both parents. When the chicks were with one parent, the other guarded the area and attempted to distract investigators from the chicks. On one occasion an adult was observed engaging in a broken wing distraction display to a river lapwing that had approached too closely. On three occasions adults were observed repeatedly diving at common sandpipers (*Actitis hypoleucos*) that had approached too closely.

Great Thick-knee (Esacus recurvirostris)

Although the study period coincided with the presumed breeding season for Great Thick-knees (Thewlis *et al.* 1998), no nests were located. Great Thick-knees were more wary of human presence than the other focal species. It was difficult to observe them, as they were very aware of the investigators presence, even from 200 m or more away. If investigators attempted to conceal themselves, great thick-knees often moved closer to keep investigators in their field of view. On one occasion a pair of Great Thick-knees was observed while investigators were hiding at the edge of a sandbar below the level of the birds at a distance of about 100 m. One individual was standing and the other "kneeling". Whenever investigators raised their heads above the sand in order to observe the pair, the "kneeling" bird would also rise up in order to better observe the investigators. When investigators lowered their heads, and the bird would again "kneel". When investigators would wait a few minutes before raising their heads again, the bird would also raise its head again. This pattern continued for as long as it was maintained by investigators (about 20 minutes). Great thick-knees were often observed sitting down or "kneeling", but in different locations on each visit. It was uncertain whether the birds observed were nesting or not. On the final day of surveys (6th May), one group of three great thick-knees was observed on a large island between Ta Veng and Voen Sai (UTM 0713800, 1552000). Only one pair of Great Thick-knees had previously been observed there, and it was assumed that the third was a juvenile, even though it appeared to be in adult plumage.

Mekong Wagtail (Motacilla samveasnae)

Although the study coincided with the breeding season for Mekong wagtails (Duckworth *et al.* 2001), no nests were located. Due to the preference of Mekong wagtails for rocky rapids and channel mosaic habitat (Davidson *et al.* 2001, Duckworth *et al.* 2001), it was often difficult to observe them for extended periods. Although Mekong Wagtails were

occasionally observed on sandbars, survey effort was focused on sandbar nesting birds, with little time allocated to observing Mekong wagtails at these locations. The majority of Mekong wagtails were found in pairs, but no obvious signs of nesting, such as carrying nesting material or food, were observed. No markedly territorial or breeding behavior such as displays, tail-chasing, or prolonged alarm calling was observed either.

Sesan River Water Levels

The Ratanakiri Water Resources and Meteorology Office records daily changes in water level in Andong Meas and Voen Sai Districts (Tables 2 and 3, Figures 1 and 2). According to raw data provided by the Ratanakiri Water Resources and Meteorology Office, mean water level changes ($\pm$ 1SD) in January - April 2003, over 48 hour periods, were 52.51 cm $\pm$ 16.06 cm at Andong Meas, and 20.53 cm $\pm$ 16.06 cm at Voen Sai. Slightly greater water level fluctuations were observed by the survey team from late February through early May than these data indicate. Water level changes were observed to generally be about 50 - 80 cm over periods of 24 - 48 hours in Andong Meas District, and less pronounced further downriver. The observed rate of change in water level was generally about 5 - 10 cm per hour as water levels were rising, and 5 cm or less per hour as water levels were subsiding.

Rainfall, measured at Ban Lung, occurred on the following dates: 31st March (90.8 mm), 6th April (15.4 mm), 20th April (105.6 mm), 29th April (31.4 mm), 3rd May (64.6 mm), 4th May (5.2 mm), and 5th May (7.2 mm) (Ratanakiri Water Resources and Meteorology Office, raw data 1st January – 7th May).

Bird Densities: Comparing Surveys 1 and 2 in 2003

Differential timing effects were tested for using paired *t*-tests to compare densities of focal bird species (numbers of birds observed/ linear km) during surveys 1 and 2 of the Sesan River in 2003 (Table 4). Great thick-knee densities on the Sesan River were significantly higher during survey 2 ($\bar{x}$ = 0.05 birds/km, SD = 0.07) than during survey 1 ($\bar{x}$ = 0.02 birds/km, SD = 0.04; t = -2.743, P = 0.02). We found no significant differences in densities of other focal species tested between surveys 1 and 2 of the Sesan River in 2003 (river lapwing: t = 0.072, P = 0.94; river tern: t = 1.099, P = 0.30; small pratincole: t = 1.179, P = 0.26; little ringed plover: t = 0.032, P = 0.76; Mekong wagtail: t = 2.092, P = 0.06). Sample sizes for black-bellied terns were too small for statistical analyses.

Differential timing effects using paired *t*-tests to compare densities of focal bird species during surveys 1 and 2 of the Sekong River in 2003 were also tested (Table 5). No significant differences were found in densities of any focal species tested between surveys 1 and 2 of the Sekong River in 2003 (river lapwing: t = -0.975, P = 0.37; river tern: t = 0.979, P = 0.41; small pratincole: t = 1.497, P = 0.19; little ringed plover: t = -0.768, P = 0.47; great thick-knee: t = -1.00, P = 0.36; Mekong wagtail: t = -1.110, P = 0.31). Sample sizes for black-bellied terns were too small for statistical analyses.

Bird Densities: Comparing Counts Between Years

Differential year effects were tested for using paired *t*-tests to compare densities of focal bird species on the Sesan River in 1998 (Timmins and Men Soriyun 1998) with 2003. River lapwing densities were significantly lower in 2003 ($\bar{x}$ = 0.45 birds/km, SD = 0.21) than in 1998 ($\bar{x}$ = 0.99 birds/km, SD = 0.47; t = -4.697, P = 0.001). Although densities of small

pratincole were much lower during survey 2 in 2003 ($\bar{x}$ = 0.65 birds/km, SD = 0.72) than in 1998 ($\bar{x}$ = 2.15 birds/km, SD = 2.25; t = -2.347, P = 0.044), differences between the 1998 survey and survey 1 in 2003 were not statistically significant (t = -1.927, P = 0.09). No significant differences were found in densities of river terns or great thick-knees between 1998 and 2003 (river tern: t = -1.205, P = 0.07; great thick-knee: t = -0.055, P = 0.96). Sample sizes for black-bellied terns were too small for statistical analyses.

A one-way analysis of variance (ANOVA) was used to test for differential year effects on densities of river lapwings, river terns, small pratincoles, and great thick-knees along the lower 85 km stretch of the Sesan River between Voen Sai and the rapids downriver of Phum Khsach Thmei in 1998 (Timmins and Men Soriyun 1998), 2000 (Poole *et al.* in prep.), and 2003. No significant differences were found in bird densities on the lower stretch of the Sesan River between years (river lapwing: F = 1.211, P = 0.33; river tern: F = 0.167, P = 0.85; small pratincole: F = 1.731, P = 0.22; great thick-knee: F = 2.378, P = 2.38). Sample sizes for black-bellied terns were too small for statistical analyses.

Little ringed plovers and Mekong wagtails were not counted in 1998, but were counted on the lower stretch of the Sesan River in 2000. Paired t-tests were used to compare densities of little ringed plovers and Mekong wagtails on the lower stretch of the Sesan River in 2000 and 2003. No significant differences in densities of little ringed plovers or Mekong wagtails on the lower stretch of the Sesan River were found between years (little ringed plover: t = 0.455, P = 0.67; Mekong wagtail: t = 1.0, P = 0.37).

Reproduction

Nest Site Selection

Water levels were constantly fluctuating, and water levels were different during each visit to a nest. In order to correct for visits to nests when water levels were extremely high or extremely low, the average measurements for each nest were used when calculating the following criteria for nest site selection for each species: sandbar length, sandbar width, sandbar area, channel width, distance of nest to the channel, and nest elevation (Table 6). The percentage of nests within five meters above or below the high water mark was 54.5% of river lapwing nests (n = 11), 8.3% of river tern nests (n = 12), 0% of the two black-bellied tern nests, 22.7% of small pratincole nests, and 45.5% of little ringed plover nests.

Nest Initiation Dates

A one-way analysis of variance (ANOVA) was used to test for synchronicity of nest initiation between focal species. Nest initiation was asynchronous between species (F = 10.387, P < 0.001). Estimations of incubation for focal species (Table 7) were based on observations, in conjunction with published probable periods for focal species (Hale 1981, Johnsgard 1981), and well-known periods for related species (Ehrlich et al 1988, Sibley 2001). Due to the large amount of time between nest checks, estimates of incubation periods are fairly rough. Due to a lack of fledgling observations, estimates of fledging periods (the time it takes a chick to fledge after it has hatched) were based on published material only (Hale 1981, Johnsgard 1981, Ehrlich et al 1988, Sibley 2001). River lapwings initiated nests the earliest, with the earliest river lapwing nest initiated around 6th February. The earliest little ringed plover nest was initiated around 25th February, with the other species did not begining nesting until March.

Still Active Nests

An "active nest" is usually defined as having viable eggs or chicks present at the original site of the nest. However, for the purposes of this study, the term "active nest" is taken to mean a nest containing eggs that have not yet hatched, since the scarcity of chick observations did not allow an assessment of chick survival to fledging. Three river tern nests, one small pratincole nest, and two little ringed plover nests were still active when the sites were last visited in early May. At least one of the still active river tern nests was known to be a re-nesting attempt, with the other two likely to be re-nesting attempts as well. The still active small pratincole and little ringed plover nests may also have been re-nesting attempts. It was estimated that hatching dates would be roughly 10th May, 19th May, and 23rd May for the still active river tern nests, 1st May for the still active small pratincole nest, and 5th May for both of the still active little ringed plover nests.

Clutch Sizes

Clutch size was two eggs for black-bellied terns, ranged from two to six eggs for river lapwings, and ranged from one to three eggs for river terns, small pratincoles, and little ringed plovers (Table 8).

Reproductive Success

Nesting attempts were considered successful if at least one egg hatched. Since estimates of incubation periods for the focal species are rough estimates only, apparent nest success was calculated, which is the proportion of nests that are successful (Table 8). Apparent nest success was 36.4% for river lapwings (n = 11), 0% for river terns (n = 9), 50% for black-bellied terns (n = 2), 85.7% for small pratincoles (n = 22), and 50% for little ringed plovers (n = 11), where "n" is the sample size. Hatching success rates (the number of chicks to hatch per breeding pair) were also clculated for the focal species (Table 8). Hatching success rates were 1.18 chicks per pair of river lapwings, 0.0 chicks per pair of river terns, 1.0 chicks per pair of black-bellied terns, 1.32 chicks per pair of small pratincoles, and 1.25 chicks per pair of little ringed plovers. It was not possible to obtain accurate estimates of fledgling success rates. The precocial chicks of many shorebird species are mobile within a couple of days, cryptic in coloration, and secretive in behavior, making it extremely difficult to gain accurate assessments of fledgling success (Erwin and Custer 1982, Smith and Renken 1993).

Flooding of Nests

Inundation was the cause of failure of nine nests of focal species (13.5% of total nests of focal species, or 37.5% of all failed nests of focal species). However, inundation was a greater factor in causing nest failures for some species than others. Inundation caused the failure of five river lapwing nests (45.5% of all nests, or 71.4% of failed nests), one river tern nest (11.1% of nests, all nests failed), neither of the two black-bellied tern nests, one small pratincole nest (4.5% of all nests, or 33.3% of failed nests), and two little ringed plover nests (25% of all nests, or 50% of failed nests) (Table 8).

At least two nests (one little ringed plover and one small pratincole, both in Andong Meas district) were flooded during one of the small, frequent rises in water level which seemed to characterize the operating schedule of the dam during the course of the study. However, the majority of nest inundations occurred during especially large rises in water level. These nests were active for one or two weeks, but then became flooded during exceptionally large water releases.

Locations of inundated nests were scattered along the whole length of the surveyed stretch of the Sesan River. The furthest downriver nest to be flooded, was a river lapwing nest located between Phum Talat and Phum Svay Rieng (UTM 0673162, 1517540), over 170 km from the Cambodia/Vietnam border, and over 240 km from the Yali Falls dam. On 10th March, the water rose to about 15 cm above the nest, a considerable rise in water level given the height of the nest above water (15 cm), the distance of the nest from the water (55 m) and the width of the river channel (about 100 m).

Egg Collection on the Sesan River

Humans collected a very high percentage of river tern eggs, on both the Sesan and Sekong Rivers. Eggs were also taken from one of the two black-bellied tern nests on the Sesan River. Due to the levels of Tern egg collection by humans, as well as the meandering patterns of many of the sets of human footprints in the vicinity of tern nests, it appears that villagers do indeed spend time trying to locate nests of terns.

On the Sesan River, all known-fate river tern nests (n=9) failed, 66.7% of which were due to collection of eggs by humans (Table 8). All unknown-fate river tern nests (n=4) were still active at the end of the study, at least one of which was a re-nesting attempt.

On the Sekong River, all river tern nests found were located on Kaoh Tbeng Island. 78% of all known-fate river tern nests (n=9) failed, 100% of which were due to egg collection by humans. Although two river tern nests successfully hatched chicks, none of the chicks successfully fledged. No juvenile river terns were observed during the second survey of the Sekong River, and all 10 pairs of river terns on Kaoh Tbeng Island had re-nested. One river lapwing nest on Kaoh Tbeng also had eggs collected by humans. This nest was only about 10 m from a river tern nest, which also had eggs collected by humans.

Incidental Disturbance and Predation on the Sesan River

Duckworth *et al.* (1998) speculate that in southern Laos, incidental disturbance probably accounts more for low breeding success of river lapwings than does direct harvesting of eggs. This may be true for river lapwings in northeastern Cambodia as well, since no egg collection of river lapwings was observed on the Sesan River. On the Sekong River, eggs were collected from one river lapwing nest on Kaoh Tbeng Island, which was in the vicinity of the river tern colony located there.

Predation by animals was the cause of failure of nine nests of focal species (13.5% of total nests of focal species, or 37.5% of all failed nests of focal species). Predation caused the failure of two river lapwing nests (18.2% of all nests, or 28.6% of failed nests), two river tern nests (22.2% of nests, all nests failed), neither of the two black-bellied tern nests, three small pratincole nests (13.6% of all nests, or 66.7% of failed nests), and two little ringed plover nests (25.0% of all nests, or 50% of failed nests) (Table 8).

Although the identities of predators were largely unknown, predation by domestic animals may occur with greater frequency in areas of higher population. All observations of domestic dogs were on mainland sandbars. Domestic dogs were usually observed wandering around alone, and only rarely were they seen accompanied by people. On two occasions domestic dogs were observed following little ringed plovers as they were engaging in broken-wing distractions. Domestic dogs and large-billed crows were attracted to sites of abandoned fishing camps and were frequently observed scavenging for food at these sites. One river lapwing nest located only a meter or so from an abandoned fishing camp was predated by a

large-billed crow, which was probably attracted to the abandoned fishing camp. One river tern nest on the Sesan River was possibly predated upon by a water buffalo. This is not impossible, as ungulates such as white-tailed deer (*Odocoileus virginianus*) in tall-grass prairie habitats in the mid-western United States have been documented eating eggs and nestlings of ground-nesting birds (pers. obs., Pietz and Granfors 2000). Water monitors and snakes also reportedly prey on eggs of sandbar nesting birds (I.G. Baird, pers. comm. 2003).

The largest colony of small pratincole observed on the Sesan River contained about fifty pairs, with birds scattered over an area about 200 m long and 100 m wide. The colony was visited on the morning of 6th April. As only two nests were located (but with minimal disturbance created), the investigators planned to return in the afternoon to search for additional nests. When investigators returned, a fishing camp had been set up in the midst of the colony, causing much distress to the birds. The fishermen informed investigators they would be there for one to two days. The fishermen were oblivious to the presence of small pratincoles in the vicinity, which made it seem unlikely that they collected any small pratincole eggs. However, their presence caused many small pratincoles to leave the area and move a few kilometers upriver, some birds possibly abandoning nests in the process. The site was revisited on 7th April. The two nests that had previously been located were situated about 150 m from the fishing camp, and although the nests were still active, only about ten pairs of small pratincole remained in the area. Numbers of small pratincole on that particular sandbar remained about the same on the subsequent visit, which was not until 26th April.

Correlations Between Bird Densities and Village Densities

Spearman's rank correlations were used to test for correlations between linear densities of villages (villages/km) and linear densities of focal species (birds/km) (Tables 4 and 5).

Linear density of villages on the Sesan River was 0.31 villages/km. Nno significant correlations were found on the Sesan River between linear densities of villages and linear densities of river lapwings ($r_s = 0.01$, $P > 0.1$), river terns ($r_s = 0.243$, $P > 0.1$), little ringed plovers ($r_s = 0.318$, $P > 0.1$), great thick-knees ($r_s = -0.191$, $P > 0.1$) or Mekong wagtails ($r_s = -0.245$, $P > 0.1$). Linear densities of small pratincoles showed a positive, rather than negative, correlation with linear densities of villages ($r_s = 0.832$, $P < 0.01$). Sample sizes for black-bellied terns were too small for statistical analyses.

Linear density of villages on the Sekong River was 0.21 villages/km. No significant correlations were found on the Sekong River between linear densities of villages and linear densities of any of the focal species tested (river lapwing: $r_s = -0.438$, $P > 0.1$; river tern: $r_s = -0.563$, $P > 0.1$; small pratincole: $r_s = 0$, $P > 0.1$; little ringed plover: $r_s = 0.446$, $P > 0.1$; great thick-knee: $r_s = 0.062$, $P > 0.1$; Mekong wagtail: $r_s = -0.286$, $P > 0.1$). Sample sizes for black-bellied terns were too small for statistical analyses.

Amount of Sandbar Habitat on the Sesan River

The linear percent of sandbars on the Sesan River was estimated to be about 15%, on average, for the entire surveyed stretch of river (Table 4). In contrast, Timmins and Men Soriyun (1998) estimated linear percent of sandbars to be greater than 60%. Water levels on the Sesan River were exceptionally low during Timmins and Men Soriyun's surveys in 1998, which influenced their perception of both linear percent of sandbars, and overall geomorphology of the Sesan River. The low water levels and correspondingly high area of

sandbar habitat in 1998 was the result of water not being regularly released during construction of the Yali Falls Dam (I.G. Baird pers. comm. 2003).

Correlations Between Bird Densities and Breeding Habitat Availability

Spearman's rank correlations were used to test for correlations between area of available habitat (unvegetated area of sandbar/km) and densities of focal species on the Sesan River and Sekong River.

On the Sesan River, significant positive correlations were found between unvegetated sandbar area and river tern densities ($r_s = 0.713$, $P < 0.02$), and between unvegetated sandbar area and great thick-knee densities ($r_s = 0.670$, $P < 0.05$). No significant correlations were found between the amount of unvegetated sandbar area and densities of river lapwing ($r_s = 0.465$, $P > 0.1$), small pratincole ($r_s = 0.128$, $P > 0.1$), little ringed plover ($r_s = 0.260$, $P > 0.1$), or Mekong wagtail ($r_s = -0.420$, $P > 0.1$). Sample sizes for black-bellied terns were too small for statistical analyses.

On the Sekong River a significant positive correlation was found between unvegetated sandbar area and densities of little ringed plover ($r_s = 0.977$, $P < 0.02$). A significant negative correlation was found between unvegetated sandbar area and densities of Mekong wagtail ($r_s = -0.786$, $P = 0.05$). No significant correlations were found between unvegetated sandbar area and densities of river lapwing ($r_s = 0.473$, $P > 0.1$), river tern ($r_s = 0.634$, $P > 0.1$), small pratincole ($r_s = 0.393$, $P > 0.1$) or great thick-knee ($r_s = 0.713$, $P > 0.1$). Sample sizes for black-bellied terns were too small for statistical analyses.

River Turbidity

An independent *t*-test was used to compare relative river turbidity of samples collected at 10 km intervals along the Sesan River, with samples collected during observations of river terns fishing in the Sesan River. No significant difference was found between the two sets of samples ($t = -1.882$, $P = 0.07$).

An independent *t*-test was used to compare relative river turbidity of samples collected at 10 km intervals along the Sesan River, with samples collected at 10 km intervals along the Sekong River. No significant difference was found between the two sets of samples ($t = 0.091$, $P = 0.93$).

Village Meetings on the Sesan River

General Presentations and Interviews

All villagers interviewed reported recent rapid declines in sandbar nesting birds. When asked what caused the declines they answered that the declines resulted from the Yali Falls dam. Villagers reported that the primary reason for the sudden declines was inundation of nests and chicks. They reported that secondary reasons for declines were loss of food sources and loss of habitat. When asked whether high levels of egg collection could have caused the decline, they replied that in the past (before the Yali Falls dam) they regularly collected eggs but had never experienced such a sudden decline in sandbar nesting birds.

Village Protection of Black-bellied Terns

On 11th-12th April investigators met with three villages, Phum Hat Pok, Phum Voen Hoy, and Phum Lumphat, to discuss strategies for protecting black-bellied tern nesting areas.

The meeting in Phum Voen Hoy was attended by the village chief and elders committee members. The general tone of the meeting was moderately positive. Although attendees were not overly enthusiastic, neither were they ambivalent or negative. Phum Voen Hoy elected to expand the role of the current village focal person (the person responsible for communicating to other villagers about various issues, and elders committee decisions) to include river bird education and awareness. The current village focal person has his swidden farm near Kaoh Romleung Island and said he often passes there. He agreed to talk with any fisher people he sees in the area about the importance of birds nesting in the area (notably black-bellied terns), and that they should not collect eggs on the island or set up fishing camps near nesting birds.

The meeting in Phum Hat Pok was attended by the commune chief, commune council members, elders committee members, and Sesan focal people (responsible for communicating information about Sesan River issues with other villagers). Meeting attendees were very enthusiastic and had very strong opinions about bird protection, and according to Mr. Meach Mean were "very clear about the birds, and very clear about protecting them". One man even proposed that they put a big fence around Kaoh Romleung Island. Meeting attendees eventually decided to post signs designating breeding bird protection areas. Although the literacy rate is low in Ratanakiri province (about 10% among men, and 2 - 3% among women) (Patterson 2000), villagers believed that signs would be a good starting point. The Hat Pok commune chief announced that he would also convince Phum Voen Hoy to put up signs on Kaoh Romleung Island and Phum Lumphat village to put up a sign at the black-bellied tern nesting site downriver from the village.

The chief of Phum Lumphat was also present at the meeting in Phum Hat Pok, but remained very quiet and made no comments during the meeting. Meeting attendance was very high and there was no opportunity to speak directly with the chief of Phum Lumphat about bird protection near his village. Protection strategies were also not discussed with other villagers in Phum Lumphat, although the survey team had visited there the previous week and interviewed villagers about river birds in their area. During the previous visit to Phum Lumphat, the chief said that he had been aware for quite some time that there is only a single pair of black-bellied terns near his village, and that he was interested in building awareness of river birds among the people in his village.

On 19 April, materials necessary for assembling four wooden signs were delivered to the Hat Pok Commune Chief. On 20th-25th April, four signs were posted in the vicinity of black-bellied tern nesting sites: two at Kaoh Romleung Island (one at the upriver end, and one on the north side facing the main channel) and two downriver of Phum Lumphat (one on the north side of the black-bellied tern nesting island, and one at a mainland sandbar about one kilometer upriver). All signs stated the following: Bird Protection Site 1.) Do not collect eggs. 2.) Do not camp. 3.) Do not walk across the sand.

Results and Observations of Non-Focal Species

Common Sandpiper (Actitus hypoleucos)
On 22nd April at 11:30 am, a group of twenty common sandpipers were observed foraging on a small (0.09 ha) sandbar at Phum Okawp, Andong Meas District. Two other sandbars (0.44 ha and 0.02 ha) were visible. At 4:00 pm all three sandbars were completely under water. All twenty common sandpipers were on a small (1 m^2) rock extending above the water. About every 15 minutes the flock would leave the rock and fly to where the sandbar had been before returning to the rock. This behavior continued through the entire two-hour observation period.

Pied Kingfisher (Ceryle rudis)
Differential year effects were tested for using a paired *t*-test to compare densities of pied kingfishers on the Sesan River in 1998 (Timmins and Men Soriyun 1998) and 2003. Pied kingfisher densities were significantly lower in 2003 ($\bar{x}$ = 0.05 birds/km, SD = 0.07) than in 1998 ($\bar{x}$ = 0.20 birds/km, SD = 0.14; t = -2.880, P = 0.02).

In 2000, only the lower 85 km stretch of the Sesan River between Voen Sai and the rapids downriver of Phum Khsach Thmei was surveyed. A one-way analysis of variance (ANOVA) was used to compare densities of pied kingfishers on the lower stretch of the Sesan River in 1998 (Timmins and Men Soriyun 1998), 2000 (Poole *et al.* in prep.), and 2003. No significant difference was found in densities of pied kingfishers on the lower stretch of Sesan River between years (F = 2.143, P = 0.16).

Two pied kingfisher nests were located during the course of the field season. The first nest, found on 21st March, was located four to five meters above the water level on a vertical earthen bank about 10 m high and 80 m long. The second nest, found on 3rd April, was located two to three meters above the water level on a vertical earthen bank eight to nine meters high and about 130 m long. Each nest was monitored for at least three weeks, although albeit was not possible to check the actual contents of each nest. The first nest was successful, as indicated by the observation of one fledged young on 22nd April. The fate of the second nest was unknown. It may have been successful, but no pied kingfishers were observed in the vicinity of the nest during the last check on 23rd April.

DISCUSSION

The Sesan River is identified as having very high regional conservation importance, as it has relatively high numbers of the focal species (Timmins and Men Soriyun 1998, Seng Kim Hout *et al*. 2003). However, villagers living near the Sesan River reported that all focal species have suffered population declines in recent years. During the two surveys of the Sesan River in 2003, significantly lower numbers of river lapwings were found than were counted in 1998 (Timmins and Men Soriyun 1998). During survey 2 in 2003, numbers of small pratincole were significantly lower than counts in 1998. Small pratincoles may have started to disperse by late April, accounting for lower counts during survey 2. However, survey 2 was closer to the time period that Timmins and Men Soriyun (1998) conducted surveys.

Sesan River Water Levels

Water level data provided by the Ratanakiri Water Resources and Meteorology Office may underestimate the actual changes in water level, since water level was not recorded hourly,

but only recorded twice daily, at 7am and 7pm, which are not necessarily the times of minimum and maximum water levels. Water level changes observed by the investigators were generally greater than those reported by the Ratanakiri Water Resources and Meteorology Office.

Bird Densities: Comparing Surveys 1 and 2 in 2003

It is surprising that, except for great thick-knees on the Sesan River, there were no significant differences in densities of focal species (numbers of birds observed per linear km) between the surveys 1 and 2 of the Sesan and Sekong Rivers. It was expected that higher numbers of birds would be recorded during survey 2, which took place towards the end of the breeding season, rather than during survey 1, which took place near the beginning of the breeding season. Although numbers of river lapwings may have increased over the breeding season, detectability of chicks was low and may account for numbers not being higher during survey 2. Also, some river lapwings may have already dispersed from the area. Detectability of small pratincole and little ringed plover chicks was low when chicks were very young (only a few days old), but did not seem especially low after chicks reached about one week or older. Movement among small pratincoles was higher towards the end of the season, and some may have already dispersed from the area. Likewise, dispersal of little ringed plovers may have already begun.

Bird Densities: Comparing Counts Between Years

Although the counts of river lapwing and small pratincole (counts from survey 2 only) were significantly lower on the Sesan River in 2003 than in 1998 or 2000, counts of other focal species were not significantly different. Nor were any of the counts of focal species on the Sekong in 2003 significantly different from counts in 1998 or 2000. However, the lower numbers of birds recorded in 2003 may be more significant than they appear, due to the higher level of coverage of sandbars resulting in more accurate counts than those obtained in 1998 or 2000. One would expect that the more accurate counts would yield higher, rather than lower, numbers of birds than those observed during 1998 and 2000.

It is unknown whether significantly lower numbers of river lapwings and small pratincole (during survey 2 only) are due to low breeding success, decreased immigration, increased emigration, or a combination of factors. All of these factors may be contributing to the lower numbers of birds if habitat quality has declined along the Sesan River.

Reproduction

Nest Site Selection—Distance of Nest to Water

Given the daily fluctuations in water level, distance of the nest to the high water mark more accurately addressed the relationship between nest location and water level, than did the distance of the nest to the current water level during a particular visit. Also, using distance of the nest to the high water mark allowed for more accurate assessments of the level of danger to individual nests from inundation. However, measuring these distances did not begin until relatively late in the field season. Only distances of the nests to obvious high water lines that were created during the latter part of the field season were observed and it was not possible to accurately estimate the distances of nests to the seasonal high water mark (Casey *et al.* 1985). Even though the measurements of nest distances to the high water mark may have been lower than if more accurate measurements of nest distances to the seasonal high water mark had

been obtained, the data show that nearly 30% of all nests of focal species were within 5 m above or below the high water mark, which puts them in a high level of danger of being inundated during rises in water level.

Reproductive Success

Since the estimates of incubation periods for focal species were rough estimates only, the apparent nest success for each species was calculated, rather than using the Mayfield method of estimating nest success (Mayfield 1975, Johnson 1979). The Mayfield method is usually preferred over using apparent nest success, because it decreases the positive bias associated with nests failing before discovery. Thus, the actual nest success of each focal species is likely to be lower than our calculations of apparent nest success suggest. Also, it was not possible to determine fledgling success rates of chicks. Therefore, only hatching success rates were used to estimate pair success.

Calculations of hatching success rates were 1.18 chicks per pair of river lapwing, 0.0 chicks per pair of river tern, 1.0 chicks per pair of black-bellied tern, 1.32 chicks per pair of small pratincole, and 1.25 chicks per pair of little ringed plover. It is difficult to determine what the implications of hatching success rates are, as the requirements are different for each species in terms of the success required to stabilize or increase the size of the population. However, these hatching success rates are not high, given the regional status of these species and the threats that they face.

Causes of Nest Failure

All focal species together suffered equal nest losses from dam-related inundation and predation by animals (excluding humans). River lapwings suffered higher losses from inundation than predation, small pratincoles suffered higher nest losses from predation than inundation, and little ringed olovers suffered equal nest losses from inundation and predation. Egg collection by humans was the leading cause of nest loss by river terns and black-bellied terns. One of two black-bellied tern nest was lost due to egg collection, and 66.7% of river tern nests were lost due to egg collection. Predation was the second highest cause, and inundation was the third highest cause of nest loss by river terns.

Egg Collection

Although egg collection most directly impacted river terns and black-bellied terns, one instance of egg collection of a river lapwing nest was observed in the vicinity of a river tern colony on the Sekong River. No egg collection of small pratincole or little ringed plover nests was observed, nor did villagers seem to give much notice to these species or their nests. Villagers interviewed on the Sesan River reported that before the Yali Falls dam was built they used to collect eggs of sandbar nesting species, but now there are too few nests and it is not worth their time to go out and hunt for them. The villagers also said that although they no longer plan in advance to collect eggs, but do so opportunistically if they happen to see them. However, it was observed that some villagers do spend time hunting for nests of river tern and black-bellied tern. . Large eggs, colonial nesting, and conspicuous behavior all serve to make tern species much more susceptible to egg harvesting than other species of sandbar nesting birds.

Chick Mortality Due to Flooding

All of the nests found were located on sandbars large enough to have at least some portion remaining above water level, even when water level rises were very large. However, there may have been nests on smaller sandbars, which were not found.

Although younger, less mobile chicks are most susceptible to drowning during water level rises, chicks of any age could be at risk along swift flowing sections of river Tern chicks may be more susceptible to drowning than the precocial chicks of river lapwing, small pratincole, and little ringed plover, as they remain in the nest for a longer period of time than the other species. Although no chicks were observed to have drowned, villagers reported observing drowned chicks this year, as well as in previous years, due to irregular dry-season water fluctuations that have occurred every year since construction of the Yali Falls dam began.

Predation of Nests by Animals

Large-billed crows were very common on both the Sesan and Sekong Rivers. The predation of at least one river lapwing nest was attributed to a large-billed row, and it is likely that large-billed crows were predators of other nests as well. They may possibly be the primary nest predator of the focal species, although more study will be required to determine the rates of predation by avian, reptilian, and mammalian predators, including domestic animals. More study will also be required to determine how large a role fishing camp sites have, in attracting nest predators such as large-billed crows and domestic dogs.

Increased Threats to Re-nesting Attempts

Although all focal species re-nested after having a first nest fail, late-season re-nesting attempts are much riskier than original or earlier nesting attempts due to increased chances of flooding when the rainy season begins. In the first week of May, there had already been three days of rain, and it appeared that the rainy season was starting early. Although three of the five nests that were still active at the end of the season were due to hatch within a few days of the last nest checks, two river tern nests were not due to hatch until later in the month. The estimated hatching dates of these river tern nests were not until about 18th May, and 21st May, which is perilously late in the season. Even after nests hatch, chicks remain vulnerable until they fledge, which may not be until four or more weeks after they hatch. Rising water levels due to rainfall is exacerbated on the Sesan River by water releases from the Yali Falls dam, putting late-season eggs and chicks in an increasingly high danger of mortality as the season progresses.

Bird Densities, Village Densities, and Habitat Availability

In southern Laos, Duckworth et al (1998) found a negative correlation between linear densities of villages and linear densities of river lapwing. We found no correlations between linear densities of villages and linear densities of any of the focal species. The findings of significant correlations between amount of available habitat (unvegetated sandbar area) and densities of river tern and great thick-knee on the Sesan River, and little ringed plovers on the Sekong River, suggest that habitat availability is a more important factor than village density in influencing bird densities. Wide, slow moving sections of river with large sandbars may be chosen more often for village locations, which may account for why small pratincole densities were positively correlated with village densities on the Sesan River. A significant negative correlation on the Sekong River between linear densities of Mekong wagtails and unvegetated sandbar area probably reflects Mekong wagtail preference for rocky rapids rather than sandbar habitat.

Impacts of the Yali Falls Dam on Focal Species

The Yali Falls dam is impacting downriver populations of sandbar nesting birds by flooding nests, altering breeding habitat, and decreasing food resources. Significantly lower numbers of river lapwings and small pratincoles (survey 2 only) in 2003 than in 1998 may also be linked to the Yali Falls dam. Dam-related inundations contributed to a large percentage of nest failures, causing 13.5% of total nests of focal species to fail, or 37.5% of all nest failures. The furthest downriver nest to by inundated was a river lapwing nest located over 170 km from the Cambodia/Vietnam border, and over 240 km downriver from the Yali Falls dam. Villagers also reported observing chicks drown during water level rises caused by the Yali Falls dam.

Although inundation of nests and chicks are the most direct impacts of the Yali Falls dam, habitat loss caused by the Yali Falls dam is also a major cause for concern. The availability of quality habitat is an extremely important factor in determining both population density and reproductive success of sandbar nesting species. Breeding and foraging habitat may be permanently lost through higher levels of erosion of sandbars with new sandbars not being created. Higher than normal dry-season water levels caused by the Yali Falls dam have decreased the availability of breeding and foraging habitat by submerging sandbars. Temporary submersion of sandbars also occurs when water levels are high.

Although the percentage of nest losses due to predation by animals was equal to that caused by inundation, predation levels may have been augmented by Yali Falls dam operations resulting in decreased area of exposed sandbars. Villagers may also have an easier time locating nests when sandbar area is decreased.

Declining food sources of riverine bird species is another negative impact of the Yali Falls dam. Fish, which are the major food source for terns, kingfishers, and fish-eagles, have declined dramatically in the Sesan River since construction of the Yali Falls dam (Fisheries Office and NTFP 2000, Baird *et al.* 2002). Villagers reported that fish catches are only a tenth of what they were before the dam. Insects and aquatic invertebrates, which are the major food source for small pratincole, little ringed plover, Mekong wagtail, and migratory shorebirds, have also declined since construction of the Yali Falls dam (Fisheries Office and NTFP 2000, Baird *et al.* 2002).

Village Protection of Black-bellied Terns

The two pairs of black-bellied terns on the Sesan River, first recorded by Timmins and Men Soriyun (1998), are possibly the only breeding birds left in the Mekong basin, as they are believed to be extinct as breeders in Thailand, Laos, Vietnam, and southern China (Van Zalinge et al 2002). The nearest breeding birds to those on the Sesan River are a small population in Burma (Van der Ven *et al.* 2000, BirdLife International 2001).

Village involvement in black-bellied tern protection is essential to their survival on the Sesan River, given the high level of egg collection of Tern species by villagers and also the threats from the Yali Falls dam. All of the villagers who attended meetings in Phum Hat Pok, Phum Voen Hoy, and Phum Lumphat (the three villages in the vicinity of black-bellied tern nesting sites) were interested in promoting awareness of sandbar nesting birds in their villages. The survey team was very encouraged by the high levels of enthusiasm shown by villagers when informed about the significance of black-bellied terns on the Sesan River. Villagers were enthusiastic about posting signs to designate bird protection sites, and made their own decisions about what the signs should say. It was our intent to present information about the

status of local bird species, while allowing the three villages to make all of their own decisions about the best way to protect and manage the nesting sites.

However, it was possible that these decisions were made too hastily. A high number of people from other villages fish on the river and use the sandbars. At least two traveling fishermen interviewed believed the signs were too suddenly posted and too harsh in their directives. If many people feel this way it could cause negative repercussions, which could possibly outweigh any benefits that the signs may have. Although, protecting breeding areas for black-bellied terns and other sandbar nesting birds was the goal of these activities, it may have been unwise to suddenly limit access to sandbars by local people. However, much of the anger of the two traveling fishermen was due to feeling left out of the process. They believed that their villages should have been consulted before the signs were posted, even though their villages were many kilometers away.

RECOMMENDATIONS AND MANAGEMENT IMPLICATIONS

Management Implications for Hydropower Operations

Unnatural water fluctuations during the dry season are impacting sandbar nesting birds on the Sesan River by flooding nests and chicks, altering breeding habitat, and decreasing food resources. Significantly lower numbers of river lapwings and small pratincoles in 2003 than in 1998 may also be linked to the Yali Falls dam. Having a flow regime which mimics the natural hydrological cycle of the Sesan River is essential to the health of riverine bird populations. Avoiding large releases of water during the height of nesting and chick rearing periods (February through May) is imperative if productivity levels of sandbar nesting bird species are to increase.

While occasional scouring flows are needed to clear vegetation from sandbars, the tropical dry-rainy season cycle assures that this occurs. Seasonal flooding is a natural phenomenon that riverine bird species are well adapted to, and that is necessary for the maintenance of a diverse river ecosystem containing a variety of quality breeding and foraging habitats, as well as food sources. Although irregular water fluctuations negatively impact riverine bird species, so does flow regulation aimed at flood control, causing the smoothing out of a river's natural seasonal variation.

Having a flow regime which mimics the natural hydrological cycle of the Sesan River is critical for fish species, as well as riverine birds. A natural hydrological regime is also highly important to villagers, who have requested that the Yali Falls dam be decommissioned and that the Sesan River be returned to its natural state. Although decommissioning the dam may not be immediately possible, mitigation measures to reduce the negative impacts of the Yali Falls dam on bird, fish, and human populations on the Sesan River should be implemented.

Prior to construction of the Yali Falls dam, environmental impact studies evaluated the down-river impacts on only an 8 km stretch of river below the proposed site of the dam (Electrowatt Engineers and Consultants 1993a, 1993b). More extensive downstream environmental impact assessments need to be conducted before construction of other dams on the Sesan River, or on other rivers of conservation significance in the Mekong River basin, such as the Srepok or Sekong Rivers, which are contiguous to the Sesan River. Negative effects of building additional hydropower dams on a river are cumulative. Although the Asian

Development Bank's initial hydropower study of the Sesan and Sekong River basins acknowledged several negative effects, as well as cumulative effects of multiple hydropower projects (Halcrow and Partners Ltd. 1998), adequate assessment of the environmental impacts of dams has been lacking by both the funders and builders of hydropower projects in the region.

Alternative sources of power that are less damaging to the environment than hydropower should be investigated.

Village Level Recommendations

All of the villagers present at discussions were interested in promoting bird awareness in their villages. However, further discussions with these villages are necessary to insure that the decision-making process is open and that proper process is followed to insure village-wide agreement and acceptance of measures taken.

The time or resources were not available to consult and discuss with every village on the Sesan River. However, it will be essential to do so in the future to ensure the support of local communities and the ultimate success of any river bird conservation measures implemented in the area.

Any material containing glossy color photos of sandbar nesting species would be immensely popular with villagers, and would be very helpful in providing information and increasing the awareness of local people about bird conservation. This should highlight the conservation significance of sandbar nesting bird species, threats during the breeding season from dam-related inundations of nests and chicks, predation, incidental disturbance, and egg collection, and ways that villagers can minimize disturbance to breeding birds.

Research Recommendations

More extensive research and monitoring should be conducted to evaluate the long-term effects of the Yali Falls dam on productivity levels of sandbar birds. In order to more accurately assess productivity levels of the focal sandbar nesting bird species, fledgling success rates need to be determined. However, more research on population sizes and trends is needed in order to ascertain the productivity levels required to maintain or increase population sizes.

Quantitative research should be conducted to evaluate the effects of the Yali Falls dam on food resources of riverine bird species.

Research should be conducted on age distribution, survivorship, site fidelity, and dispersal rates and patterns to provide further information regarding population dynamics of sandbar nesting birds in the Mekong River basin.

Research is also needed on fish population requirements, how dam-related changes in water chemistry and turbidity levels have affected water quality, and how water quality has affected wildlife and human populations.

Research on the geomorphology of the Sesan River, including river channel morphology, sedimentation and erosion patterns, and other physical and hydrological dynamics is crucial

to understanding the long-term ecological consequences of the Yali Falls dam. By minimizing morphological changes to the Sesan River channel, many of the physical habitat requirements for riverine birds, fish, and other species can be maintained.

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Table 2. Sesan River water levels and water level changes, during 48 hour periods, at Andong Meas District from 1st January through 30th April 2003 (from raw data provided by the Ratanakiri Water Resources and Meteorology Office).

	January	February	March	April
Mean water level (m) (± 1SD)	2.99 ± 0.40	2.84 ± 0.29	2.99 ±0.37	2.93 ± 0.31
Range of water levels (m)	2.50 - 3.77	2.43 - 3.41	2.01 - 3.45	2.39 - 3.41
Mean change in water level (cm) (± 1SD)	46.93 ± 23.94	41.75 ± 18.26	64.81 ±28.77	54.33 ± 16.83
Range of water level changes (cm)	8.0 - 89.0	15.0 - 76.0	30.0 - 144.0	26.0 - 98.0

Table 3. Sesan River water levels and water level changes, during 48 hour periods, at Voensai District from 1st January through 30th April 2003 (from raw data provided by the Ratanakiri Water Resources and Meteorology Office).

	January	February	March	April
Mean water level (m) (± 1SD)	3.01 ± 0.18	2.81 ± 0.16	2.92 ± 0.13	2.79 ± 0.14
Range of water levels (m)	2.70 - 3.46	2.30 - 3.00	2.68 - 3.20	2.52 - 3.00
Mean change in water level (cm) (± 1SD)	27.45 ± 25.73	18.43 ± 11.47	16.20 ± 7.62	20.10 ± 11.64
Range of water level changes (cm)	4.0 – 104	4.0 - 40.0	6.0 - 40.0	4.0 - 48.0

Table 4. Counts of focal species and other important species during surveys of the Sesan River. On the top line are counts from survey 1, and on the bottom line are counts from the survey 2. Numbers in parentheses are the numbers of groups.

Stretch #	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
From (UTM)	0764180 1526106	0754800 1531800	0744350 1541000	0736750 1554400	0728400 1554350	0722800 1558300	0711000 1553750	0699800 1545000	0696000 1545250	0690250 1545000	0679750 1528400	0673600 1517000	0660000 1512550	
To (UTM)	0759933 1526366	0744350 1541000	0736750 1554400	0728400 1554350	0722800 1558300	0711000 1553750	0699800 1545000	0696000 1545250	0690250 1537750	0679750 1528400	0673600 1517000	0660000 1512550	0658050 1512850	
Date	10/3	20-21/3 22/4	21/3 23/4	21/3 23/4	27-28/2 24/4	27/2 24/4	27/2 24/4	27/2 24/4	21/2 25/4	21/2 25/4	21-22/2 25-26/4	22/2 26/4	11/3 26/4	
River lapwing	6 (2)	7 (4) 9 (6)	9 (5) 3 (2)	8 (5) 10 (6)	2 (1) 0	13 (6) 31 (10)	13 (5) 11 (6)	2 (1) 0	8 (4) 6 (3)	10 (11) 8 (4)	16 (8) 22 (12)	8 (4) 1	0 0	102 101
Small pratincole	5 (1)	38 (1) 17 (1)	2 (1) 0	19 (3) 24 (2)	5 (2) 0	2 (1) 0	34 (2) 4 (1)	41 (1) 0	31 (2) 5 (1)	10 (1) 28 (3)	9 (2) 35 (2)	27 (3) 38 (2)	0 0	223 151
Great thick-knee	0	0 1	0 0	0 0	0 0	2 (1) 3 (2)	0 0	0 0	0 0	2 (1) 4 (2)	1 2 (1)	0 1	0 0	5 11
River tern	0	1 1	0 0	3 (2) 1	0 0	4 (2) 5 (2)	4 (1) 4 (3)	1 0	2 (2) 1	6 (3) 9 (3)	5 (3) 6 (2)	8 (5) 4 (3)	0 0	34 31
Black-bellied tern	0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	2 (1) 0	2 (1) 4 (3)	0 0	0 0	4 4
Little ringed plover	1	8 (3) 13 (5)	2 (1) 3 (3)	3 (2) 8 (5)	2 (2) 0	7 (4) 16 (5)	7 (4) 11 (3)	4 (2) 0	9 (6) 12 (4)	18 (9) 11 (4)	16 (8) 6 (3)	3 (1) 1	0 0	80 81
Mekong wagtail	12 (4)	5 (4) 5 (3)	6 (3) 1	1 1	1 0	6 (3) 4 (4)	0 0	0 0	0 0	0 0	0 0	0 0	2 (1) 1	33 12
Pied kingfisher	0	2 (1) 2 (1)	1 0	2 (1) 0	2 (2) 0	0 0	1 0	0 0	0 0	0 0	0 0	2 (1) 0	1 1	11 3
Brahminy kite	0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	2 (2) 0	0 0	1 0	0 0	0 0	3 0
Grey heron	0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0
Woolly-necked stork	0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0
Osprey	0	0 0	1 1	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 1

River Length (km)	8	20	20	12	8	20	20	5	18	23	22	20	2	198
# of Villages	3	8	4	7	9	3	8	3	7	3	2	5	0	62

Table 5. Counts of focal species and other important species during surveys of the Sekong River. On the top line are counts from survey 1, and on the bottom line are counts from survey 2. Numbers in parentheses are the number of groups.

Stretch #	1	2	3	4	5	6	7	Total
From (UTM)	0650400 1560400	0648250 1553650	0641650 1540750	0636100 1524850	0633650 1519950	0626450 1512800	0617250 1502400	
To (UTM)	0648250 1553650	0641650 1540750	0636100 1524850	0633650 1519950	0626450 1512800	0617250 1502400	0611500 1498600	
Date	28/3 29/4	28/3 29/4	28/3 29/4	28/3 29/4	28/3 29/4	28/3 29/4	28/3 29/4	
River lapwing	1 0	0 1	12 (7) 8 (3)	4 (3) 1	3 (3) 2 (1)	7 (3) 6 (1)	0 1	27 19
Small pratincole	0 0	17 (1) 15 (2)	13 (3) 14 (1)	0 0	4 (1) 1	0 0	3 (1) 2 (2)	37 32
Great thick-knee	0 0	0 0	1 2 (1)	0 0	0 0	0 0	0 0	1 2
River tern	1 0	4 (2) 0	23 (5) 24 (5)	4 (2) 1	5 (4) 8 (5)	2 (1) 4 (3)	1 1	40 38
Black-bellied tern	0 0	0 0	0 0	1 0	0 0	0 0	0 0	1 0
Little ringed plover	1 1	3 (1) 4 (1)	1 2 (1)	0 0	0 0	5 (1) 3 (1)	0 1	9 11
Mekong wagtail	0 4 (1)	1 2 (1)	1 1	0 1	5 (4) 4 (4)	0 0	1 5 (3)	8 17
Pied kingfisher	0 2 (1)	0 0	0 0	0 0	0 0	0 0	0 0	0 2
Grey heron	5 (1) 0	0 0	0 0	0 0	0 0	0 0	0 0	5 0
Woolly-necked stork	0 1	0 0	0 0	0 0	0 0	0 0	0 0	0 1
River Length (km)	7.5	15.5	12	6	21	17	7.5	86.5
# of Villages	6	5	1	1	1	2	2	18

Table 6: Nest site selection of sandbar nesting birds on the Sesan River, 22nd February – 6th May 2003. Sites where chicks were found after hatching, were included .

	River lapwing			River tern			Black-bellied tern			Small pratincole			Little ringed plover		
		1 SE	n		1 SE	N		1 SE	n		1 SE	n		1 SE	n
% of nest sites on mainland bars	69		14	36		25	78		18	17		12	0		2
% of nest sites on islands	31		14	64		25	22		18	83		12	100		2
Sandbar length (m)	423.1	128.5	14	230.0	108.0	25	405.6	291.9	18	504.2	272.6	12	285.0	233.4	2
Sandbar width (m)	100.8	39.5	14	68.4	43.7	25	71.4	45.6	18	179.6	107.7	12	115.0	49.5	2
Sandbar area (ha)	4.4	2.6	14	2.0	2.3	25	2.7	1.8	18	11.5	12.2	12	3.9	4.1	2
% sand	88.1	25.0	14	66.4	40.3	25	88.1	22.3	18	82.9	11.4	12	90.0	14.1	2
% gravel	5.8	12.6	14	18.6	21.8	25	6.9	12.3	18	9.2	7.9	12	5.0	7.1	2
% vegetation	6.2	12.4	14	15.0	19.8	25	4.4	11.0	18	7.9	6.2	12	5.0	7.1	2
Channel width (m)	97.0	37.5	11	87.1	25.0	22	86.0	29.1	10	113.2	22.2	11	67.5	10.6	2
Nest elevation above water level (cm)	64.6	97.8	11	34.3	25.0	22	15.0	8.1	11	72.5	59.1	12	62.5	53.0	2
Distance of nest to channel (m)	46.9	28.1	11	33.9	20.9	22	31.6	22.8	11	102.3	47.7	12	99.5	79.2	2
Distance of nest to high water mark (m)	9.7	30.9	11	19.9	19.8	22	-0.3	52.6	11	72.5	66.8	12	55.0	22.1	2

Table 7: Estimated nest initiation, hatching, and fledging dates of focal bird species located on the Sesan River, 22nd February through 6th May 2003. Estimated dates are included for failed nests and broods that were found after hatching.

	River lapwing			River tern			Black-bellied tern			Small pratincole			Little ringed plover		
		1 SE	n		1 SE	n		1 SE	n		1 SE	n		1 SE	n
Estimated incubation period	24 days			22 days			22 days			20 days			22 days		
Earliest nest initiation	6 Feb.		13	2 Mar.		12	25 Mar.		2	5 Mar.		25	25 Feb.		18
Latest nest initiation	1 Apr.		13	30 Apr.		12	31 Mar.		2	9 Apr.		25	11 Apr.		18
Mean nest initiation	28 Feb.	16.0	13	4 Apr.	18.6	12	28 Mar.	4.2	2	23 Mar.	11.8	25	26 Mar.	14.5	18
Earliest hatch date	5 Mar.		13	26 Mar.		12	16 Apr.		2	26 Mar.		25	19 Mar.		18
Latest hatch date	25 Apr.		13	23 May		12	19 Apr.		2	1 May		25	5 May		18
Mean hatch date	25 Mar.	15.0	13	25 Apr.	21.0	12	18 Apr.	3.5	2	14 Apr.	11.8	25	19 Apr.	14.8	18
Estimated fledging period	28 days			28 days			28 days			28 days			28 days		
Earliest fledging date	2 Apr.		13	23 Apr.		12	9 May		2	23 Apr.		25	16 Apr.		18
Latest fledging date	23 May		13	20 Jun.		12	14 May		2	28 May		25	2 Jun.		18
Mean fledging date	22 Apr.	15.0	13	23 May	21.0	12	12 May	3.5	2	23 May	11.8	25	17 May	14.8	18

Table 8: Clutch sizes, reproductive success, and nest loss of focal species on the Sesan River, 1st January through 6th May 2003.

	River lapwing			River tern			Black-bellied tern			Small pratincole			Little ringed plover		
	Mean	1 SE	n	Mean	1 SE	n	Mean	1 SE	n	Mean	1 SE	n	Mean	1 SE	n
Clutch size	3.20	1.32	10	2.22	0.44	9	2.00	0.00	2	1.67	0.58	21	2.00	0.67	10
% of nests that were successful	36.4	14.5	11	0.0	0.00	9	50.0	35.4	2	85.7	7.5	22	50.0	17.7	8
Chicks hatched/pair	1.18		11	0.00		9	1.00		2	1.32		22	1.25		8
% of nests inundated	45.5		11	11.1		9	0.0		2	4.5		22	25.0		8
% of nests lost to egg collection	0		11	66.7		9	50.0		2	13.6		22	25.0		8
% of nests predated	18.2		11	22.2		9	0.0		2	0.0		22	0.0		8

Table 9. Relative Abundance of Bird Species Observed Between 22 February and 6 May

C = Common, several or more records per day in appropriate habitat
U = Uncommon, one or more records per week
R = Rare, fewer than one record per week
P = Present, incidental records where abundance was not assessed.

Because of the short amount of time spent on the Sekong River, it was not possible to determine whether less common species should be recorded as "Uncommon" or "Rare". Therefore, the category "Uncommon" was used for all species observed with relatively low frequency on the Sekong River.

Common Name	Latin Name	Sesan River	Sekong River
Red junglefowl	*Gallus gallus*	P	
Duck sp.	*Anas sp.*	U	
Black-headed woodpecker	*Picus erythopygius*	P	
Grey-headed woodpecker	*Picus canus*	P	
Common flameback	*Dinopium javense*	P	
Lineated barbet	*Megalaima lineata*	C	P
Coppersmith barbet	*Megalaima haemacephala*	P	
Oriental pied hornbill	*Anthracoceros albirostris*	P	P
Green bee-eater	*Merops orientalis*	U	
Chestnut-headed bee-eater	*Merops leschenaulti*	C	C
Common kingfisher	*Alcedo atthis*	R	
Blue-eared kingfisher	*Alcedo meninting*	R	
Stork-billed kingfisher	*Halcyon capensis*	C	U
White-throated kingfisher	*Halcyon smyrnensis*	U	U
Black-capped kingfisher	*Halcyon pileata*	U	U
Pied kingfisher	*Ceryle rudis*	U	U
Cuckoo sp.		P	
Green-billed malkoa	*Phaenicophaeus tristis*	P	
Greater coucal	*Centropus bengalensis*	C	P
Indian roller	*Coracias bengalensis*	C	
Dollarbird	*Eurystomus orentalis*	P	
Blossom-headed parakeet	*Psittacula roseate*	C	C
Parakeet sp.	*Psittacula sp.*	C	C
Parrot sp.		C	C
Silver-backed needletail	*Hirundapus cochinchinensis*	C	C
Brown-backed needletail	*Hirundapus giganteus*	P	
Needletail sp.	*Hirundapus sp*	C	C
Asian palm swift	*Cypsiurus balasiensis*		P
Crested treeswift	*Hemiprocne coronata*	C	C
[Mountain] imperial pigeon	*Ducula badia*	C	
Green pigeon sp.	*Treron sp.*	P	
Spotted dove	*Streptopelia chinensis*	C	C
White-breasted waterhen	*Amaurornis phoenicurus*	U	
Snipe sp.	*Gallinago sp.*	R	
Eurasian curlew	*Numenius arquata*	R	
Common greenshank	*Tringa nebularia*	C	C
Green sandpiper	*Tringa ochropus*	U	
Common sandpiper	*Actitus hypoleucos*	C	C
Great thick-knee	*Esacus recurvirostris*	U	U

Black-winged stilt	*Himantopus himantopus*	U	U
Little ringed plover	*Charadrius dubius*	C	C
Kentish plover	*Charadrius alexandrius*	R	
River lapwing	*Vanellus duvaucelii*	C	C
Red-wattled lapwing	*Vanellus indicus*	U	
Small pratincole	*Glareola lactea*	C	C
Caspian tern	*Sterna caspia*		P
River tern	*Sterna aurantia*	C	C
Black-bellied tern	*Sterna acuticauda*	U	U
Osprey	*Pandion haliaetus*	U	
Fish-eagle sp.	*Haliaeetus sp.*		P
Black kite	*Milvus migrams*	R	
Brahminy kite	*Haliastur indus*	U	
White-rumped vulture	*Gyps bengalensis*	R	
Red-headed vulture	*Sarcogyps calvus*	R	
Shikra	*Accipiter badius*	P	
Accipiter sp.		P	P
Rufous-winged buzzard	*Butastur liventer*	P	
Oriental honey-buzzard	*Pernis ptilorhyncus*	P	
Changeable hawk eagle	*Spizaetus cirhatus*	P	
Little egret	*Egretta garzetta*	C	C
Grey heron	*Ardea cinerea*	U	U
Purple heron	*Ardea purpurea*	R	
Cattle egret	*Bubulcus ibis*	C	C
Chinese pond heron	*Ardeola bacchus*	C	C
Pond heron sp.	*Ardeola sp.*	C	C
Little heron	*Butorides striatus*	U	U
Darter	*Anhinga melanogaster*		U
Little cormorant	*Palacrocorax niger*		U
Cormorant sp.	*Phalacrocorax* sp.		U
Wooly-necked stork	*Ciconia episcopus*	R	U
Greater racket-tailed drongo	*Dicrurus paradiseus*	C	C
Drongo sp.	*Dicrurus sp.*	C	C
Large-billed crow	*Corvus macrorhynchos*	C	C
Oriole sp.	*Oriolus sp.*	P	
Blue whistling thrush	*Myaphonus caeruleus*	P	
Brown flycatcher sp.	*Musciapa sp.*	P	
Blue flycatcher sp.	*Cyornis sp.*	P	
White-rumped shama	*Capsychus malabaricus*	P	
Black-collared starling	*Sturnus nigricollis*	C	C
Common myna	*Acridotheres fuscus*	P	
White-vented myna	*Acridotheres grandis*	C	C
Hill myna	*Gracula religiosa*	C	
Chestnut-bellied nuthatch	*Sitta castanea*	P	
Barn swallow	*Hirundo rustica*	C	C
Dark-necked tailorbird	*Orthotomus atrogularis*	P	
Tailorbird sp.	*Orthotomus sp.*	P	P
Warbler sp.	*Phylloscopus sp.*	P	P
White-crested laughingthrush	*Garrulax leucolopus*	P	

Mekong wagtail	*Motacilla samveasnae*	C	C
White wagtail	*Motacilla alba leucopsis*	U	
Grey wagtail	*Motacilla cinerea*		U

Table 10: Observations of Important Bird and Mammal Species, 22nd February – 6th May 2003.

Common Name	Latin Name	Date	Sesan	Sekong	Notes
Black-bellied tern	*Sterna acuticauda*	22 Feb. - 6 May	X		Two pairs consistently present.
		29 Mar.		X	Single bird.
Eurasian curlew	*Numenius arquata*	7 Mar.	X		Group of three birds.
Woolly-necked stork	*Ciconia episcopus*	28 Feb.	X		Single bird perched in tree on the riverbank.
		6 Apr.	X		Singe bird on a sandbar.
		29 Apr.		X	Single bird in river at Phum Dan Loung (1), only 20 m from two fishermen.
Grey heron	*Ardea cinerea*	23 Feb.	X		Single bird.
		21 Mar.	X		Single bird.
		23 Mar.	X		Group of four birds.
		28 Mar.		X	Group of five birds.
		29 Mar.		X	Same group of five birds as 28 March.
		6 Apr.	X		Pair of birds.
Purple heron	*Ardea purpurea*	4 May	X		Pair of birds flying over river.
Darter	*Anhinga melanogaster*	29 Apr.		X	Single bird.
Great cormorant	*Phalacrocorax carbo*	29 Mar.		X	Two birds about 1 km apart.
Little cormorant	*Phalacrocorax niger*	29 Mar.		X	Two single birds.
Brahminy kite	*Haliastur indus*	20 Feb.	X		Single adult bird.
		23 Feb.	X		Single adult bird.
		27 Feb.	X		Single immature bird.
		23 Mar.	X		Single adult bird.
		5 Apr.	X		Single immature bird.
		7 Apr.	X		Single adult bird.
		11 Apr.	X		Single adult bird.
Black kite	*Milvus migrams*	27 Feb.	X		Single bird.
		28 Mar.		X	Single bird.
		6 Apr.	X		Single bird.
Rufous-winged buzzard	*Butastur liventer*	22 Feb.	X		Single bird.
Fish-eagle sp.	*Haliaetus sp.*	29 Mar.		X	Single bird.
White-rumped vulture	*Gyps bengalensis*	24 Mar.	X		Group of 14 (7 adults and 7 immatures) about 10 km downriver from Voensai. One adult attempting to feed on half-submerged water buffalo carcass. The rest of the birds on a small island about 10 m away.
Red-headed vulture	*Sarcogyps calvus*	6 Apr.	X		Pair of birds on a sandbar near Phum Svay Rieng, thermoregulating with wings outstretched.
Long-tailed macaque	*Macaca fascicularis*	11 Mar.	X		Single individual.
		23 Mar.	X		Group of 10.
Otter sp.		21 Mar.	X		Single set of tracks on an island about 20 km downriver from Ta Veng.

Table 11. Gazetteer of localities mentioned in the text

Locality	District	Province	UTM Coordinates
Andong Meas district center (Phum Okawp)	Andong Meas	Ratanakiri	0748700, 1534400
Ban Lung	Ban Lung	Ratanakiri	0715000, 1520000
Kaoh Romleung Island	Voen Sai	Ratanakiri	0681000, 1529300
Kaoh Tbeng Island	Sesan	Stung Treng	0634500, 1527400
Phum Bo Kham	Andong Meas	Ratanakiri	0754800, 1531500
Phum Hat Pok	Voen Sai	Ratanakiri	0683600, 1531000
Phum Lumphat (Phum Bat Lao)	Kon Mum	Ratanakiri	0679500, 1526500
Phum Khsach Thmei (Phum Sai Samee)	Sesan	Stung Treng	0662000, 1511400
Phum Phi	O Yadao	Ratanakiri	0765400, 1526100
Phum Svay Rieng	Sesan	Stung Treng	0667000, 1515200
Phum Talat	Sesan	Stung Treng	0674900, 1523500
Phum Voen Hoy	Voen Sai	Ratanakiri	0681600, 1532600
Siem Pang	Siem Pang	Stung Treng	0650100, 1560100
Stung Treng town	Stung Treng	Stung Treng	0605000, 1496000
Ta Veng district center	Ta Veng	Ratanakiri	0728400, 1554300
Voen Sai	Voen Sai	Ratanakiri	0696300, 1545000

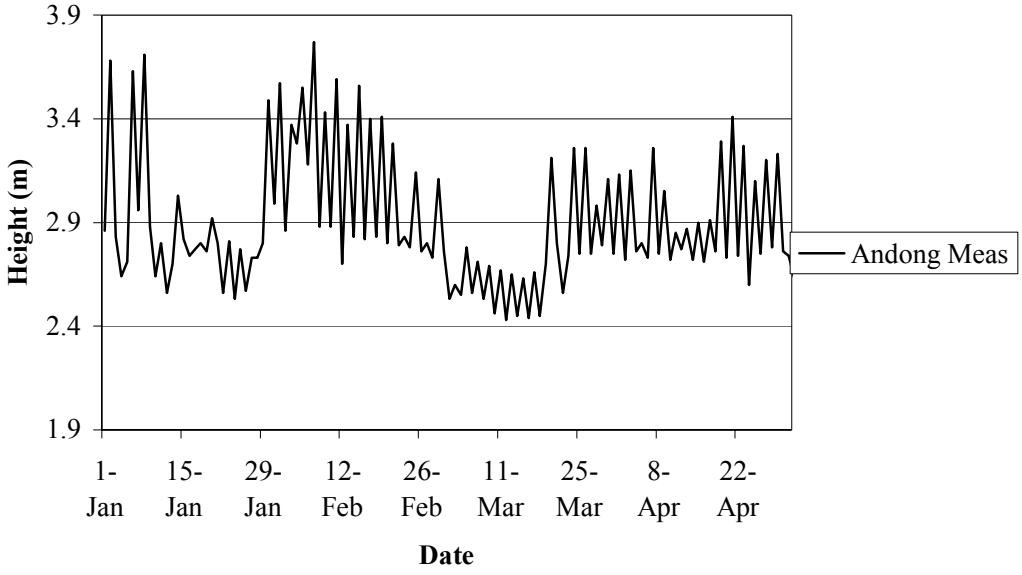

Figure 1. Water level (m) on the Sesan River at Andong Meas, 1st January – 30th April, 2003.

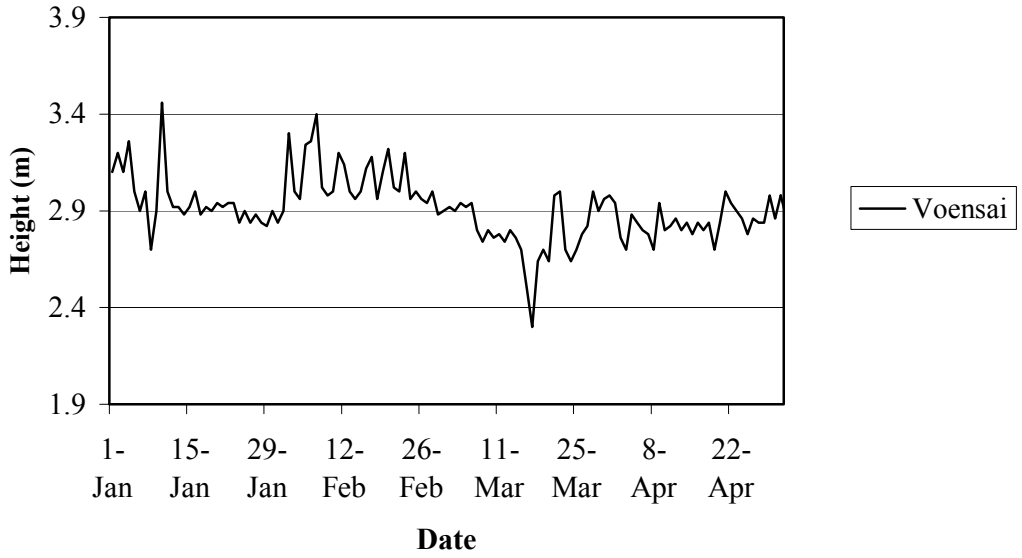

Figure 2. Water level (m) on the Sesan River at Voensai, 1st January – 30th April, 2003

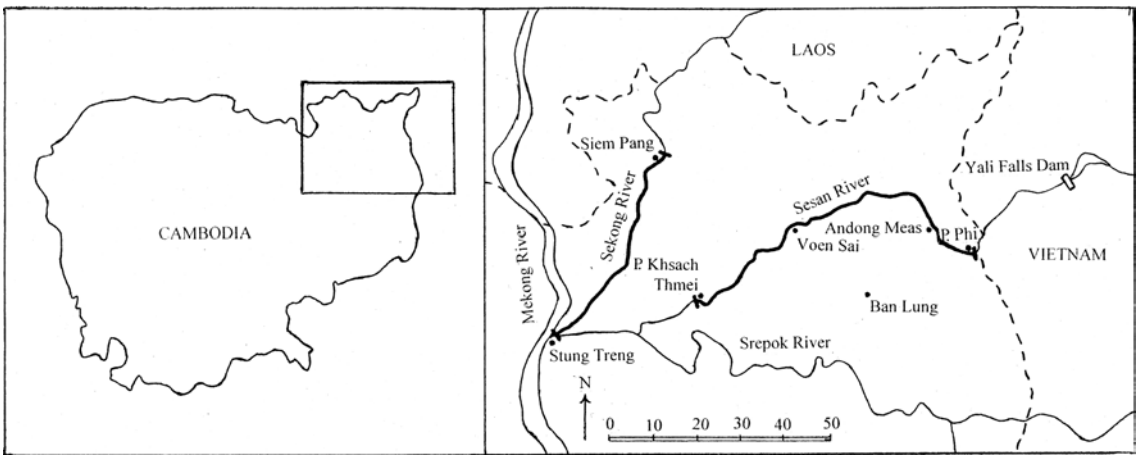

Figure 3. Location of study area in the region and map of study area. Surveyed sections of the Sesan and Sekong Rivers are marked with thick black lines, international boundaries are marked with dotted lines.

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