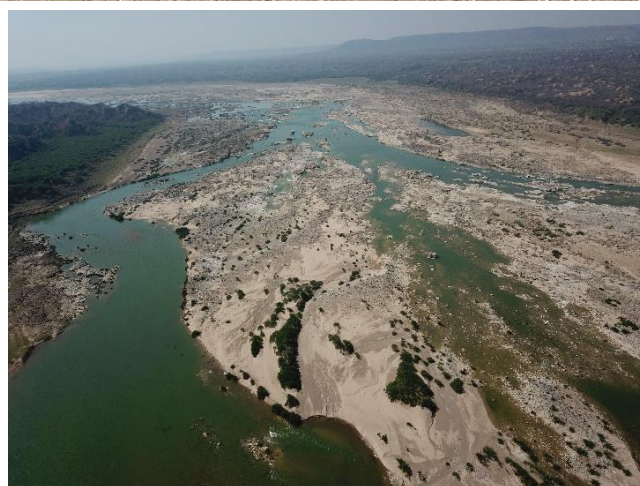


ACTIVITIES REPORT

GHARIAL ECOLOGY PROJECT

JANUARY-DECEMBER 2022



In collaboration with Madras Crocodile Bank Trust, Gharial Local & Global Foundation,
Uttar Pradesh Forest Department, Madhya Pradesh Forest Department,
Rajasthan Forest Department & Ministry of Environment, Forest, and Climate Change

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PROGRESS REPORT. GHARIAL ECOLOGY PROJECT 2022

Introduction: The Gharial Ecology Project (GEP) completed its 15th field season(2022), since its initiation in 2008, following the mass die-off of Gharial (*Gavialis gangeticus*) in the winter of 2007-08. Our research, supported by the international zoo community and private donations, is sanctioned under the NGO umbrella of the Madras Crocodile Bank Trust (MCBT). The GEP programs are facilitated by the State Forest Departments of Uttar Pradesh, Madhya Pradesh, and Rajasthan, as well as the Ministry of Environment, Forests, and Climate Change, Gov't of India. The GEP is the present-day avatar of the Gharial Conservation Alliance, and our media presence has increased through active Facebook and Instagram pages, a dedicated YouTube Channel, and soon to be inaugurated new website. What follows is a brief summary of recent activities during the calendar year 2022, updating Lang et al. (2018, 2021).

The GEP has three main goals: 1) to develop a comprehensive assessment of gharials in the National Chambal Sanctuary (NCS), 2) to identify and protect the species' critical riverine habitats, and 3) to reduce threats and challenges to the species' continued survival. Gharials are Critically Endangered (=CR) with an estimated 750-800 mature adults globally; 650+ are resident in the NCS. Project activities are conducted primarily by a small core staff (3-4) of Indian biologists / naturalists, with periodic inputs from its Senior Scientific Advisor, Professor Jeff Lang. Active, productive collaborations with Indian colleagues are encouraged locally and regionally, as well as international level collaborations globally.

Volunteer Participation (January-December 2022). Professor Jeffrey W. Lang is a retired academic biologist who has worked in Indian conservation since 1983, when he first visited the Madras Crocodile Bank, on his return from a two year post doc in Australia. He worked in south India during the 1980s and 1990s on mugger crocodiles, and then returned to India to work on the Chambal with Rom Whitaker and Dhruvajyoti Basu when there was a catastrophic die-off of gharial in the NCS. He contributes personal resources for his international travel and in-

country expenses, and relies on the international zoo community for project support. As in previous years, as Senior Scientific Advisor to the Gharial Ecology Project, I spent nearly full time throughout 2022 managing and working on various aspects of the project. USD support from primarily CROCFEST and selected US zoos pay for the telemetry gear, and for the photo, imaging, and recording devices used to document gharial activities and behaviors.

In 2022, following relaxing of the covid restrictions barring travel to India, I made 3 extended work trips to join the GEP field team on the Chambal. In Mar-May 2022, I was at the Garhaita base for 59 days, with in-country trips to Hyderabad and to Son, as well as to Nepal to extend my Indian visa. Later in June, I returned for 29 days during pre-monsoon when creche behaviors were being studied and filmed. During both spring-summer trips, I worked closely with Jailabdeen on mss/chapters of his PhD thesis on gharial communication, specifically acoustic studies of POPs and pheromonal glandular secretions. In mid Nov, I returned for 34 days, to join the team catching and radiotagging gharial from upstream to downstream locations. In addition, I made a 10 day trip to Prague to attend two international meetings focused on crocodylians and gharials. Jailabdeen A. was also able to join me in the Prague visit which gave him a chance to meet Czech supporters and zoo staff from all over Europe. All of the funding for international travel is contributed by me, and no funds for the GEP are used for international travel and related expenses, only my personal funds.

During the calendar year 2022, funding from the City of Prague/ Prague Zoo provided major salary support for the Indian field team on the Gharial Ecology Project (GEP). The GEP field crew consisted of Jailabdeen A., Pankaj K., Anand K., and "Guddhu" K. In addition, wages were provided for Dr. Ashutosh T. and an assistant for conducting targeted village meetings and programs about the Chambal River species, riverside environments, and conservation topics, such as recycling, tree planting, and watershed ecology. In this activity summary report, we outline selected topics with approximate timelines to provide a snapshot of the scope and breadth of the Gharial Ecology Project's activities during 2022.

The primary study site now extends throughout the ~450+ kms of the lower mainstream Chambal and its tributaries, comprising a major portion of the National Chambal Sanctuary (NCS). This is a Protected Area sanctioned by the Gov't of India, and controlled locally by each of the states, Madhya Pradesh, Uttar Pradesh, and Rajasthan. Significant travel times and expenses are now a regular component of the GEP operation and logistics (1-3 days travel /visit) from the upstream to downstream bases, supported largely by Indian CSR funding.

The NCS is subdivided, for purposes of our study, into a downstream section, from Rhea (at border of UP-Rajasthan) to below the Yamuna confluence at Pachnada, an upstream section, from the Parvati-Pali junction to Rahu Ghat, a major waterfall site. The midstream section of our study site in the NCS is centered near Dholpur-Morena, and ranges up to Rahu Ghat and down to Rhea.

Tracking gharial tagged with radios (January-December 2022). Each tracker is tasked with monitoring the locations and observing the activities and behaviors of gharial residing in the NCS. Tracking is done throughout the entire year, with emphases on breeding, nesting, and hatching activities, primarily during January to July. Long field sessions, often extending over 24 hrs, away from home, typify the daily, weekly, and seasonal activities of the trackers, during the chilly winter period as well as the intense pre-monsoon dry heat, and stifling high humidity and ambient temperatures during the monsoonal, two month rainy, high water season. In July-September, the monsoonal monitoring is focused on longer seasonal movements and feeding aggregations at confluences and mainstream tributaries. Post monsoon movements and activities are followed during September thru December each annual cycle.

In 2022, 20 radioed gharial from tagging in late 2021 were the primary individuals that were tracked throughout the entire year, from Jan thru Dec. Of the 26 gharial tagged in late 2021, 3 individuals went missing immediately after tagging, and were not subsequently located to date. All three missing gharial were from the midstream; these were radios 10, 93, and 40/11. A fourth individual was

transported to the Son Gharial Sanctuary (radios 46/08; see section below for full description of this translocation). All but 2 of the remaining radio-tagged gharial were located at least once by manual tracking of the VHF unit that identified each animal. Sixteen of the 20 tagged gharial were residents of the midstream section, and 4 resided in the downstream stretch. Of these, 5 gharial were also outfitted with satellite GPS transmitters that recorded daily locations periodically, in addition to manual tracking (see separate section below). Overall, a total of 224 locations were logged by manual tracking of the 22 radioed gharial during 2022. The number of locations per animal ranged from 2 to 29, and averaged about 10 locations per gharial.

In 2022, 11 additional gharial radiotagged in late 2020 were also still being tracked, along with the 2021 tagged gharial. This was a smaller subset of 3 downstream individuals, for a total of 31 locations, as well as 8 upstream gharial, for 34 locations. The downstream animals were primarily tracked in early 2022 before their radios ceased functioning, during April through August. The upstream gharial tagged in late 2020 were tracked pre-monsoon (n=4; Feb-Jun) and then after the monsoon (another 4; Oct-Dec). In nearly all instances, the tracked gharial were consistently residential within relatively short, confined stretches of river, and were ultimately located close to wherever each was captured and tagged, regardless of whether the location was upstream or downstream.

Altogether, 31 gharial outfitted with radio tags (20 from 2021 tagging; 11 from 2020 tagging) were monitored continuously by 3 trackers during 2022, in most instances biweekly or monthly, throughout the year. In 2022, this routine required frequent periodic visits to the upstream, midstream, and downstream stretches of the NCS; each stretch spans approximately 150 kms of the mainstream Chambal.

Seasonal movement patterns (January-December 2022). For the 20 gharial (tagged in 2021; tracked in 2022), 16 were from the midstream Chambal, and 4 were from the downstream. Each individual displayed one of three residential patterns: a) minimal movements (~1 km), b) short movements (~3-5 kms), or

c) longer movements (>20 kms). Three of the downstream animals showed minimal movements (04,03,06), and one displayed short movements (47/07). For those residing in midstream, 8 showed minimal movements (24,85,87,89,83,93,30, 44/16), and 3 showed short movements (63,61,95). Two of the midstream gharial moved >20 km upstream during the monitoring period (15,90). Overall, the midstream residents showed a wide variety of movement patterns than either the upstream animals studied to date, or those residing in the downstream. Characteristically, upstream gharial were predominately stationary, showing little to no movements seasonally. In strong contrast, downstream residents typically moved downstream during the monsoon, at times over moderately long distances seasonally.

For the other 11 gharial (tagged in 2020; tracked in 2022), 3 were from downstream and 8 were from upstream. The three downstream gharial were essentially residential with minimal movements during the April to August monitoring periods. The eight upstream gharial tracked in 2022 consisted of four residents with minimal movements during Feb-Jun, and another 4 residents monitored post monsoon, from Oct-Dec, with similar patterns of restricted movements, either minimal or within short distances.

Iridium satellite GPS tracking units (January-December 2022). In late 2021, 8 gharial were additionally outfitted with expensive (USD1500/unit) Iridium satellite GPS logging radios, in addition to a conventional VHF tracking unit (USD200/unit). In brief, each iridium unit tag logs daily GPS locations, and periodically transmits these data to an internet site displaying a "kml" graphic map of animal locations, with corresponding date/time. One of these animals was transferred to another sanctuary site, and is discussed in a separate section. Of the other 7 units deployed, 2 malfunctioned immediately and yielded no usable information. The other 5 units provided detailed information (186-436 datapoints; for 236-522+ days) on a subadult (a male) and 4 adults (3F;1M). Two of these females (57/17; 62/12) moved upstream >50+kms to breed and/or nest, while the third (50/20) moved >250+ kms downstream during the monsoon, and into the lower Yamuna,

after she had bred and nested upstream. Post monsoon, manual tracking located this individual returning to her earlier late 2021 capture location, at the top of the midstream stretch, by end October.

The single adult male monitored extensively during 2022 via the satellite GPS locations exhibited extensive long distance movements throughout the midstream stretch presumably related to mobility in an effort to secure opportunities to breed and/or guard at nest sites. In particular, he made a very long >100 km movement upstream during the monsoon period to a major waterfall area, likely acting as a barrier to further upstream movement. Then, after a period, he returned to a favored area where he resided during the breeding and nesting periods in 2022, and then again in 2023. At present, he is still being monitored remotely via the satellite link, with 436 data points extending over 522+ days at the end of April 2023. The other male, a subadult, also resided midstream, but showed little movement outside of a limited 10-20 km stretch of river, over a 249 day period until mid August 2022; 186 datapoints indicated very limited movements, with specific dates/times.

The relative importance of the Chambal gharial population is evident. With realistic estimates of all the other populations included, the total number of adult gharials globally likely remains under 1000 today. Consequently, the NCS population constitutes about 80% of the world total. Nesting in the NCS likely exceeds 85% of the global total annually. Presently, the NCS population is the only remaining population residing in an open riverine, largely protected habitat. Importantly, it is self-sustaining, definitely stable, and appears to be on the increase in recent years. However, major threats loom large, including widespread and uncontrolled water extraction, rampant riverside sand mining at many nesting sites, and ubiquitous illegal net fishing throughout the NCS.

Outreach Activities (February-May 2022). In 2022, Dr. Ashutosh Tripathi, the GEP Outreach Coordinator, spent 26 days full time as Consultant, planning, producing, and conducting various outreach programs and activities. An assistant helped him with these activities, plus considerable travel time and expense to travel full days back and forth to the upstream base early in 2022. In February-

March 2022, from the 21 Feb thru 13 Mar, 12 community programs were conducted in neighboring riverside villages in and near our upstream base. These included Katrinapur where our base is located, as well as Rijheta, Baroli, Rampura, Herapura, Jamudhi, Nadigaon, Dubabali, Raghunathpur, Nimach, and Kahupura. These were half day awareness programs that required a day's preparation to organize and publicize. In addition, on Mar 4th, a capacity building workshop was conducted for the MPFD at Kuno National Park, the future site for a "cheetah reintroduction" program later in 2022. Later in May, from 15th-25th, Ashutosh and his assistant conducted similar programs in 5 riverside villages near the Chambal-Yamuna confluence area, near Bhareh. These included the villages of Dadra, Bahaliyapura, Chakarpura, Ritor ki Madaiyan. Although there were plans to continue with community programs in the downstream stretch near Etawah, Dr. Tripathi resigned unexpectedly in early June to take a permanent position as Assistant Professor at a state university. For this reason, community programs were not conducted during the remainder of 2022, and funds allocated for that purpose were used for tracking gharial.

Drones deployed (January-December 2022). In 2022, we have been using DJI quadcopter drones to create 2D and 3D maps of riverine habitats, using geo-referenced JPEGs. Drone imagery facilitates species identification (mugger vs. gharial), quantification of numbers present, as well as accurate estimates of animal sizes. With regard to finding and counting nests, aerial methodology is reliable when colony size is mid-range, >5 but <20 nests. In general, drones are well tolerated by gharials on land or in the water at $>50\text{m}$ height, but disturbances increase rapidly at lower altitudes. Within large crèches, counting hatchlings accurately is possible with drone-acquired imagery. Related software has allowed 3D imagery of nesting banks for detailed analyses of nest placement, relative to water levels, and nearby nests.

Gharial Population Surveys (January-March 2022). As in previous years, the GEP field team conducted systematic stationary and boat counts surveys over the entire length of the NCS, e.g. upstream, midstream, and downstream stretches.

These extend from the Parvati tributary in upstream MP, through the entire upstream stretch (Parvati-Pali=50+km; Pli-Dang Basai= 140+km), then from midstream to downstream (Dang Basai-Rhea=130+km), and finally the downstream stretch (Rhea-Pachnada=130+km) to the NCS downstream boundary, ~10+km beyond the Yamuna-Chambal confluence.

In 2019 through 2021, the total population count, based on encounters during the peak basking season (late Jan-early Feb) had tallied ~400 gharial in the upper half of the NCS (above Dholpur; >200km above confluence), and ~1300 gharial in the lower half of the NCS (below Dholpur; <200 km above confluence). In late Jan 2022, stationary counts were initiated in the upstream stretch, and continued in the midstream through mid-February, and then in the downstream. In mid March, the GEP also participated in a downstream boat survey.

In early 2022, our estimation of the total gharial population in the NCS was 1673 individuals, consisting of 148 males, 696 females, 442 subadults, 262 juveniles, and 125 yearlings. The upstream vs. downstream distribution is similar to that observed in previous recent surveys. Roughly 621 gharial inhabit the upstream habitats, with a preponderance of adults and subadults (61 males; 316 females, 158 subadults), vs. smaller size classes (86) consisting of juveniles (66) and yearlings (20). In the downstream, the 1052 gharial counted consist of 87 males, 380 females, 284 subadults, and 196 juveniles and 105 yearlings. A boat survey by the UPFD in mid-Feb 2022 counted 961 gharial from Rhea to confluence vs. 1052 by GEP stationary count at same locations.

Breeding observations/filming (February-March 2022). Jailabdeen A. and film maker Suman spent 3 weeks in late February documenting multiple breeding males, in their respective breeding arenas, along and near the very large colony nesting site near Nadigoan, in the upstream where 67 nests were laid in late March and early April. Specific breeding behaviors were documented, with audio and video records, of male-male interactions, as well as courtship and mating sequences. Two trackers made additional breeding activities at various other upstream and midstream sites during Feb-Mar 2022. In addition, a third tracker was stationed in the downstream to monitor the established breeding areas near nesting sites used repeatedly, year after year.

Nest surveys-Post Hatching (June-July 2022). In 2022, 506 gharial nests were recorded by surveys immediately post-hatch, as well as during hatching at selected nest sites. This number represents an increased nesting effort of 84 nests, relative to the nests tallied in 2021, $n=422$. Of the 506, 414 nests hatched, whereas 85 were predated (early=21; late=64). The largest nesting colony, on record to date, a mid-river island at Nadigoan, near the upstream base, contained in total 67 nests, of which 59 hatched successfully, and 8 were predated. Nest locations in 2022 numbered 35, nest number/site ranged from 1 to 67, with a median of 15 nests/site (1-5=13 sites; 6-10 nests=7 sites; 11-15 nests=4 sites; 16-20 nests=2 sites; and >30 nests=5 sites). At the other largest nest colony, Khera in the downstream, in 2022, 38 nests hatched successfully, and 14 were predated, out of a total of 52 nests. At Khera, nesting was concentrated into two pockets, on ~100m of steep (45-50 degree) sand bank. The flat surface above the nests failed to prevent jackals from approaching and predating upper level nests. At Nadigoan, in contrast, a series of sandbanks with 10 indentations/pockets provided protection from jackal predation from above.

Creche counts (June-July 2022). In recent years, frequent (almost daily) counts of hatchlings visible in creches have been made until each large group of hatchlings disperses, in an attempt to document survivorship of hatchlings in the days post hatch. Generally, each creche tends to remain grouped near the nesting site as long as the water levels remains low, prior to the start of monsoon rains and river edge flooding. Representative counts at large and small creches are available for 2022. Observations were made at 15 sites, with nest numbers ranging from 1 to 51 when counts were made. Highest number of hatchlings was 2015 at Nadigoan with 51 nests hatched, but hatchling numbers dropped to 880 less than 3 weeks later. Nest predation was highest at the sites with the most nests. Several sites with only 1-2 nests showed relatively high survivorship. The drop in hatchling numbers by the end of 4 weeks post hatching are difficult to interpret, simply as losses due to predation, since creches tend to organically disperse and spread over greater shoreline distances, as the hatchlings grow and begin to feed regularly, while remaining loosely grouped prior to high water.

Male transfer to Son Gharial Sanctuary (January-August 2022). In mid December 2021, the GEP field team captured and transported a big ghara male gharial (4.9m=TL; ~560 kg=WT) from the lower Chambal to the Son Gharial Sanctuary (SGS) by road within the MP borders, an approximate distance of ~800 kms, which took 33+ hrs from capture to release. This translocation was initiated in late 2020, and took 1.5+ yrs to organize and obtain necessary permissions and funding from the MPFD. The GEP collaborated fully in this venture, and provided tracking radios for the released gharial. Once released, the transplanted male was monitored by the MPFD as well as the GEP, requiring frequent visits/trips during January-August 2022. These were focused on breeding, nesting, incubation, and hatching, and post hatching activities at Jogdha, the release site where 4-5 adults females resided and had previously nested when two adult males had been present earlier prior to 2015.

In summary, the results of this transfer were exceptional. The transplanted male immediately settled at the release site, and began basking within a few days with the resident females. Previously, breeding had occurred every year from early 2000s thru 2014, until in 2015 the two resident males died due to illegal netting. In late February 2022, courtship and mating were observed, and in late March, 4 nests were laid which subsequently hatched in late May, producing ~120 hatchlings. The creche was attended by the nesting females, accompanied by the new resident male, having parented the SGS 2022 nests.

Unfortunately, the transplanted male shifted downstream to Bihar during the monsoon, was captured and released >400+ kms away in the Gandak River, despite efforts by the MPFD to return him to the 2022 transplant site in the SGS.

Capture and tagging gharial (November-December 2022). The GEP field team, with the direction and leadership of Jailabdeen A. and Pankaj K. had another successful catch and tag session on the Chambal in late 2022. The trackers and Jai work with an experienced group of local fishermen from Pachnada who have been netting and handling gharial since 2008 when the project started. Kishore,

his son Pinto, and relatives Shiv Singh, Santaram, and Prem Narian spend long hours setting nets, patiently waiting for gharial to become entangled, then expertly capture and restrain each gharial. A total of 35 resident wild gharial were tagged with radio transmitters, including 10 with Iridium satellite transmitting tags that convey GPS location information (for more detail on these units, see a following section of this report). The primary area of focus within the NCS were all three NCS sections containing gharial: the upstream, primarily near our upstream base at Baroli to Nadigoan, the midsection stretch, from Dang Basai above Dholpur (on the Gwailor-Agra road) to just above Reha (at the Raj-UP border), and downstream, from Reha to near Naangoan, above our downstream base at Garhaita. The majority of tagged gharial were females (27 of 35), including 16 adults or 'near' adults (>2.9m total length), and 11 sub-adults (<2.9m). Two "big ghara" males were also tagged (3.5m and 4.2m total length), as well as 6 sub-adult males.

To date, noteworthy new findings, using this methodology, have included: 1) documentation of behavioral interactions among the multiple males resident at or near the upstream breeding groups, 2) discovery of multiple nests on an upstream tributary (Kuno River) not previously known to be used seasonally by Chambal gharial, 3) tracking a downstream resident female up into the mid stretches of the NCS, where she subsequently breed and likely will nest nearby in 2021, 4) tracking a midstream female who bred near her capture site, nested ~60 km downstream, and then traveled all the way to the confluence and lower Yamuna during the monsoon, 5) tracking two females which moved upstream to breed and nest, and 6) recovery after 7 years, of a juvenile marked in 2013 with radio in the downstream.

Head-starts vs. wild juveniles (December 2022). In late 2022, members of the GEP catch and tag field crew (Jai, Guddhu, and Jeff) were assisted by Karthik Vasudevan of LaCONES, and two young MSc graduates from Nepal who were visiting the tagging operation. The MPFD at the Deori EcoCentre had previously selected and processed captive-reared gharial that were destined for release in

the NCS in early 2023. We radiotagged 20 "head-starts" with small VHF radios for tracking their survival, growth, and movements, post release. Starting in late 2018, we have been working in collaboration with the MPFD to track head-started 2-4 yr old juvenile gharials, reared at the Deori EcoCentre facility near Morena in Madhya Pradesh. In comparisons of wild resident vs. reared "head-starts," matched for size/age, wild juveniles had higher rates of survival and showed well-defined and stable patterns of residence, without notable residency shifts and/or long dispersals. In contrast, fewer "head-starts" survived, and were more likely to shift residences and/or move long distances. Furthermore, released captive-reared gharial were more likely to be predated by muggers (subadults and adults). In fact, we were able to track several subadult muggers for several months before they eventually voided the "head-start" radios in feces. "Head-starts" also showed atypical behaviors, and had distinctly different activity patterns, during the first few months following release, than those of wild residents living alongside them.

Kuno connection (December 2022). Discovery of the importance of the Kuno National Park as seasonal gharial habitat, through its connections with the NCS has spurred a new found interest by the Madhya Pradesh Forest Department (MPFD) in gharial conservation and protection in this specially designated and protected area. The Kuno NP, an additional >80 kms of river is also being used as an additional release site for "head-started" juvenile gharial, from the Deori EcoCentre.

We continue to partner with the MPFD, and Deori "head-starts" tagged in late 2022 were released in early 2023, in Kuno, as well as in several midstream localities where wild resident juvenile gharial were tagged during the 2022 catch and tag operation. In December 2020, we tagged 11 head-starts, 6 for release in Kuno, and 5 for release at the Baroli sandbank on the main Chambal. At the end of March 2021, all 11 of these juveniles are actively being tracked, with most remaining near release sites. Post monsoon 2021, a few of these tagged "head-starts" were located near the release site in Kuno NP, but at least one from Kuno had moved into the mainstream Chambal. Several of the "head-starts" released

near Baroli in the upstream Chambal, above the Kuno confluence, were tracked post monsoon. Overall, indications are that only about half of those released as "head- starts" were evident a year later post release. Widespread movements and/or mugger predation are suspected as factors leading to this result.

Again, in 2022, no recently tagged gharials ventured into the Kuno for nesting. Notably, when water levels are markedly low, nesting may be restricted. In October 2021, at least one subadult female resided well within the Kuno NP, but there is little evidence of a resident gharial population in Kuno.

Upstream base, downstream office (January-December 2022). In 2022, we finished furnishing our new upstream base at Katrinapur, a small riverside village, is located within a 15 minute walk to the Baroli sandbank on the Chambal River. It serves as a stand alone office-workroom with adjoining bath-toilet facilities, and was built in 2020-2021, with additions in 2022. Its proximity to the two major breeding and nesting areas on the upper Chambal make it possible to conduct detailed behavioral observations every day, and this location also facilitates week to month long stays in the upstream, and allows day trips to adjacent mainstream stretches, as well as tributary river habitats. Previously, this upstream location was a focal point for gharial surveys and releases of captive-reared juveniles from Deori EcoCentre, by the MPFD. Downstream, we have continued to maintain and improve our riverside village base at Garhaita, most recently with A/C units to help control ambient conditions at suitable temperature and humidity levels for computers, electronic and photographic equipment. Back up generator and inverter allow us to operate periodically independent of local mainline power line.

Prague Zoo-Krokodylii Zoo visits (October 2022). In early October, Jailabdeen A. and I met in Prague, traveled to Pisek, visited the Plzen Zoo, then participated in the European Crocodile Network Meeting 2022 in Protivin on 8-9 Oct at the Krokodylii Zoo, then returned to the Prague Zoo where we stayed 10-14th Oct. On 11th Oct, we gave talks during Gharial Day, hosted by the PZ and the Czech Herp. Society, and later attended tours and talks with PZ staff, including Petr Velensky.

Other gharial researchers attended and participated in these activities, notably Phoebe Griffith working at Chitwan in Nepal on gharial, and Kent Vliet, the CAG Coordinator for the US Zoos. The PZ get together was organized and graciously hosted by Professor Ivan Rehak, and CHS volunteers.

Gharial genetics (January-December 2022). Final data analyses and preliminary write ups of the two genetic studies of Chambal gharial were completed in 2022, with periodic visits with our collaborators at LaCONES, a satellite facility of Centre for Cellular & Molecular Biology (CCMB) in Hyderabad. Jai and I traveled in April 2022 to spend a week with Dr. Karthik Vasudevan and Ravi Singh; later in 2022, Karthik joined us during the catch tag operation in early December in midstream Chambal. A novel 15 marker panel has been developed which is much more informative than previous markers. With a new panel of markers, a genetic bottleneck event in the Chambal population is clearly evident. Furthermore, detailed parentage analyses show evidence of multiple paternity, within nests as well as within nesting sites. This suggests that multiple males are fathering nests in nest colonies, and that females from different breeding sites are nesting together. Alloparenting by guardian females and males appears to be widespread at Chambal colonial nesting sites, where >20 females nest in groups, at times >60 nests together, resulting in very large creches of 100's, sometimes >1000 hatchlings at a site. In light of these new markers, previous studies are being re-evaluated.

Gharial communication (January-December 2022). Jailabdeen A. has continued his PhD research studies of acoustic signaling amongst "big ghara" males. In 2022, Professor Lang and Jailabdeen spent weeks at Garhaita during March thru May analyzing, drafting, and revising versions of two mss outlining Jai's acoustic studies. Gharial signals consist of underwater POPs in stereotypic patterns, primarily with "timing" variations, which are individually distinctive as well as context-dependent. In short, adult male gharial are signaling using fine structured temporal patterning of POPs, very different than the frequency-based vocal signals described in other crocodylian species. How the POPs are produced as well as perceived are open questions, ripe for further studies.

Jai is also investigating chemical signaling via secretions produced in the gular and cloacal glands. Pheromone samples from wild gharial of various sizes, ages, and sexes have yielded complex mixtures of distinctive chemical compounds. Such secretions are presumably responsible for the noticeably strong, musky smell made by large male gharials during breeding, but the roles of pheromonal communication in other aspects of gharial behaviors are largely unknown. Jai will complete his PhD later in 2023.

International Funding (January-December). We are extraordinarily fortunate to have the continued support of the City of Prague / Prague Zoo and the generous contributions of donors to CrocFest through the Gladys Porter Zoo. The Summer CrocFest (June 2021) at Zoo Tampa provided additional support for the Gharial Ecology Project, and we gratefully acknowledge the invaluable funding received to date, literally making gharial conservation on the Chambal an on-going joint venture and a distinct reality. The international zoo continues to contribute support via the CrocFest events, as well as direct support; Berlin Zoo, Montgomery Zoo (Alabama), and the Los Angeles County Zoo have provided substantial funding in the past two years. We have begun to garner CSR funding from Indian industry, and gratefully acknowledge the extraordinary logistic and operational funding provided by the Astral Pipes Foundation, as we solicit additional CSR support.

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