Effects of Human Disturbance on Colonial Species, Particularly Gulls

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Colonial birds are particularly vulnerable to human disturbance because of the large concentrations of birds nesting in close proximity. Vulnerability varies depending on species, nest location, and the type of disturbance (see Manuwal 1978). Nearness to human activities is one key factor, as the potential for disturbance is much greater regardless of a species' intrinsic vulnerability. Mere distance is not sufficient to assess the potential for disturbance because the surrounding habitat affects human (or predator) access. Birds nesting a half mile from a town on an island surrounded by deep, rough waters are surely less vulnerable than those surrounded by solid ground. Similarly, nesting habitat is crucial: nests on cliffs are less accessible than are nests on flat ground, nests in trees are less accessible than are ground nests, and burrows are less accessible than are surface-areas. Ground-nesting species such as gulls, terns, and some herons, egrets, ibises, and cormorants are thus particularly vulnerable to human disturbance because they are accessible and often nest in close proximity to human activities.

The types of human activity that affect colonial bird populations are varied, ranging from overall destruction to direct intervention such as entering colonies, collecting eggs, and killing adults, eggs, or chicks. The response of colonial birds to human activities varies markedly, but no species can withstand the direct effects of killing adults, eggs, or chicks for sustained periods of time. Assessing the effects of human disturbance on nesting colonial birds is a difficult task because the observer can never completely remove himself. The problem is further complicated by the decreased accuracy of success measurements with fewer egg or chick censuses. Observation of reproductive success from afar is usually impossible in the egg stage, and is complicated in the chick phase by the presence of vegetation and rocky or uneven terrain.

Reproductive success can be lowered either directly by causing desertion of nests, eggs or young, by adults, or indirectly by causing thermal stress, predation, and cannibalism. In this paper I discuss the direct and indirect ways human activities affect colonial birds, particularly Larids, and I report on some of the sub-lethal effects of human disturbance including behaviors contributing to the lowered reproductive success. I present results on the behavioral responses of gulls, terns, and skimmers to human disturbance including decreased egg and chick attendance, shifts in the mate incubating, movements and entanglements of chicks, higher brood sizes, and greater aggressive interactions.

GENERAL METHODS

The results presented in this paper were gathered in several gull, tern and skimmer colonies from 1970 to 1980 including Islajo, Carvel, and Clam Islands (New Jersey), Cedar Beach and Jamaica Bay Refuge (New York), Isles of Shoals (Maine), Agassiz National Wildlife Refuge (Minnesota), and at Murphy (Argentina). The specific methods employed to observe the effects of human disturbance varied and will be described in the appropriate sections.

RESULTS

Nest Attendance

When disturbed frequently, gulls can respond either by habituating (i.e. remaining at the nest) or by decreasing nest attendance. While studying Herring Gulls (*Larus argentatus*) on Clam Island, New Jersey in 1977 (see Burger 1979 for description of Clam Island) I compared adult behavior in one section where my assistants

walked through the colony for 30 min. every other day (=disturbed) with a second section in front of my hide where no one walked among the birds. These data were taken in an area with bushes, where gulls could not see the intruder until he approached, but they could see other gulls flying above the head of the intruder. In the disturbed section the gulls flew when my assistants were 10-12 m from the plot, whereas in the undisturbed section the gulls did not fly when the assistants approached (but walked by) as close as 5 m. The gulls in the undisturbed section had apparently habituated to the nearby presence of humans (who never came into their area), while the birds in the disturbed section responded quickly to an approaching human. Although the birds in the undisturbed section did not actually see the intruders, they did see the cloud of mobbing gulls above the intruder's head, and apparently habituated to this mobbing behavior.

Disrupted Incubation

In most gulls the sexes spend equal amounts of time incubating eggs and brooding chicks (see Burger 1980a). Repeated disturbance may disrupt this equal sharing of incubation and brooding activities if the sexes behave differently after a disturbance. In 1977 I watched 12 pairs of Herring Gulls from a blind (8-12 hr/day) during the incubating period. All birds were color marked for individual identification. These birds, in a disturbed section, were visited every other day for 30 min. during the incubation period. I saw 11 disturbances, which provided 132 opportunities for the disturbed birds to resume incubation after the disturbance. Males incubated after a disturbance more often than expected by chance ($\chi^2 = 13.2$, df = 1, $P < .01$). That is, males incubating before a disturbance usually resettled on nests, whereas when females were disturbed while incubating, their mates (when present) resumed incubation after the disturbance. Males did not allow females to incubate the eggs for some time afterwards.

In Black Skimmers (*Rynchops niger*), both sexes are usually present during the day (Erwin 1977). While studying 11 nests of skimmers at Cedar Beach, Long Island, I found that males usually resumed incubating after a disturbance ($\chi^2=8.0$, df=1, $P < .005$, based on 36 exchanges). Presumably, energy demands are similar for birds incubating and for their mates standing nearby. However, during the brooding phase, the non-brooding parent not only rests nearby, but chases intruders that land near the nest, and periodically flies off to obtain food for the young. Thus, females displaced from brooding might be expending more energy foraging and defending nests than they would be doing in an undisturbed colony.

Aggressive Behavior

Human disturbance in gull colonies also increases the rate of aggressive behavior toward conspecifics as well as towards human intruders. I examined the changes in aggression rates of Herring Gulls toward a human intruder on Clam Island, New Jersey in 1978. I made observations each week from early April to June, from hides in two habitats; grass (*Spartina patens*), and bushes (*Iva sp.*) As an intruder walked steadily through the area, I recorded the number of diving gulls, the mean height of the dives above the intruder's head, the number of dives, and the number of attacks on conspecifics in 1 min. samples (10 per habitat). For both habitats the number of divers, dives, and conspecific attacks increased, while the mean height above the intruder's head decreased toward hatching (Fig. 1 and 2). For all measures, the re-

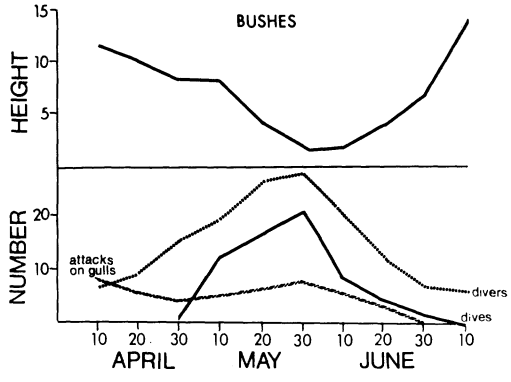

Fig. 1. Top: Mean height of Herring Gulls diving at a human intruder in the bush habitat. Bottom: Number of Herring Gulls diving, the number of dives, and the number of conspecific attacks in bushes as a function of season.

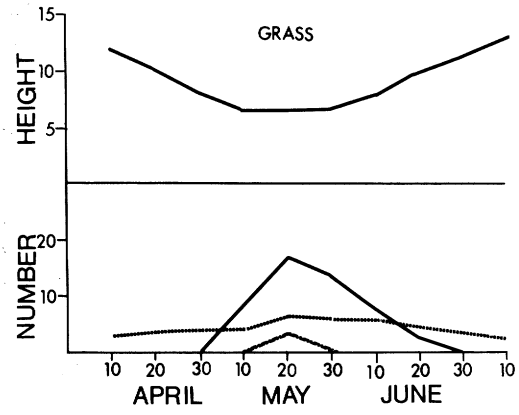

Fig. 2. Top: Mean height of Herring Gulls diving at a human intruder in the grass. Bottom: Number of Herring Gulls diving, the number of dives, and the number of conspecific attacks when a human intruder walks through the grass habitat.

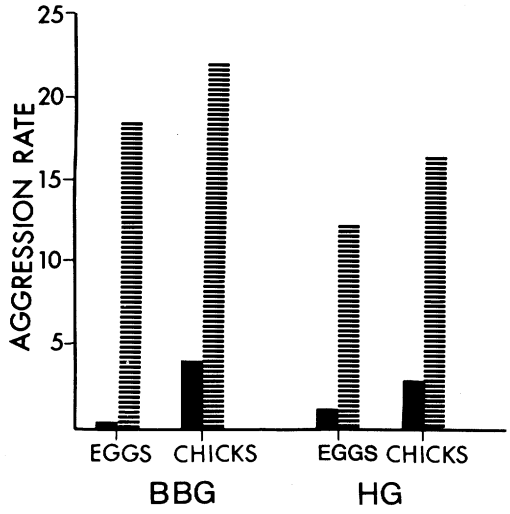

Fig. 3. Mean aggression rate (number of encounters/bird x hour) when humans walked through the area (hatched bar) and when the birds were undisturbed (solid bar). BBG = Great Black-backed Gull, HG = Herring Gull, Eggs = birds were incubating, chicks = parents had chicks over one day old.

sponses were more intense in the bushes compared to the open grass. This difference was partially due to differences in nesting density. In the bush habitat several gulls nested within 5 m of each other, whereas internest distances in the grass habitat rarely were as low as 8 m. Gulls nesting in the bushes usually (at hatching) flew to within 2 m of the intruder's head and frequently struck his head; whereas gulls nesting in the grass never touched the intruder and rarely came closer than 5 m. Thus, aggression stimulated by the presence of a human varied temporally with stage of nesting and as a function of nest density and habitat.

I further examined disturbance-induced changes in aggressive behavior in a mixed species colony of Herring Gulls and Great Black-backed Gulls (*L. marinus*) located on Appledore Island (Isles of Shoals, Maine, see McGill 1977), in late May and early June 1980. Both species were studied in rocky areas with low, sparse grass or on bare rock outcrops. I selected one plot that contained about 20 pairs each of nesting Black-backed Gulls and Herring Gulls. While I observed both species, other investigators periodically walked through the plot checking nests and young. I recorded the number of aggressive interactions as a function of species and nesting stage (eggs or chicks), and collected similar data one hr after their departure. I computed a mean aggression rate (number of encounters/bird x hour, see Fig. 3). For both species, aggression rates were lower in the egg phase (May) compared to the chick phase (early June); and lower in the undisturbed period compared to the disturbed period. When two people walked through the plot aggression rate for Herring Gulls were about five times greater, and those for Black-backed Gulls were four to 18 times greater than they were in periods when the birds were not being disturbed. I then examined the aggressive behaviors involved (Fig. 4). When undisturbed by humans both species tended to use low intensity behaviors toward an avian intruder, such as walking toward the intruder, long-calling, grass-pulling, or flying at the intruder (ground chase). Such encounters rarely evolved into ground fights (physical contact), aerial chases, or aerial fights; and were usually over in a few seconds. During human disturbances, both species were involved in more intense aggression of longer duration. When disturbed by humans over 75% of Herring Gull interactions involved fights in the air. In general, Black-backed Gulls were involved in less intense interactions than were Herring Gulls (Fig. 4).

Other forms of human activity such as airplane noise can also cause changes in aggressive behavior. While studying nesting gulls on Canarsie Pol (Jamaica Bay

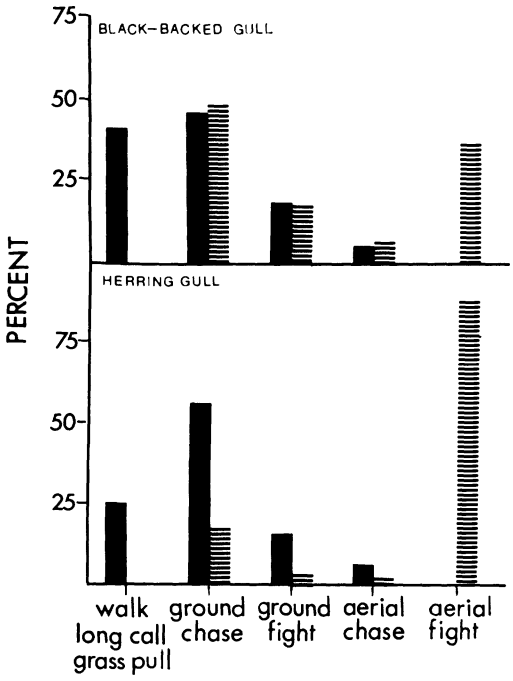

Fig. 4. Behaviour of gulls toward gulls when a human was in the area checking nests (hatched bar) compared to when no human was in the area (solid bar).

National Seashore, New York) I noted that the gulls seemed to respond differentially to the noises produced by supersonic transports compared to noises emitted by other kinds of aircraft. Thereafter, I recorded the noise level, number of birds flying over a prescribed section, and the number of fights/min. Whenever a plane flew over the colony, and at 1 min. intervals beginning one minute after the plane had passed (Table 1). Fights involved physical contact, and usually lasted for 1-5 min. I distinguished the supersonic transport (SST) from all other airplanes. These observations showed that the noise levels were higher, more birds flew overhead, and more fights occurred when the SST flew over than when non-SST's flew over, or during periods when no air traffic occurred. My observations were made during late incubation after the gulls had had two to three months to habituate to the supersonic transport planes (see Burger 1980b). During the chick stage, the passage of an SST often resulted in prolonged fights between adults, whose chicks were then exposed to attacks from other neighbors or intruders not directly involved in the territorial clashes. Several researchers have noted the effect of helicopters on colonial birds when the aircraft flew too close to the colony (J. Rodgers pers comm, Kushlan 1979).

These data indicate that when disturbed, gulls engage in more aggression of a higher intensity. This aggression is directed both at the intruder and towards other gulls. Such interactions result in their eggs or young being unattended while they chased away another gull. Although these aggressive interactions do not appear to alter territory size or shape, they nonetheless involve an expenditure of energy and expose the eggs or chicks to potential predation.

TABLE 1. Behavior of nesting Herring Gulls when exposed to subsonic airplanes, supersonic transports, and normal colony noises. Noise levels are in decibels on the A scale.

	Normal	Non-SST[1] Planes	SST	F[2]	P
Noise Level (dB-A)					
Mean	77.0 ± 3.7	91.8 ± 3.6	108.2 ± 3.8	364.3	< 0.001
Range	72 - 83	88 - 101	101 - 116		
Number of Birds Flying Overhead					
Mean	11.7 ± 3.3	11.0 ± 2.9	137 ± 40.5	173.6	< 0.001
Range	8 - 18	8 - 16	36 - 220		
Number of Fights[3]					
Mean	0.1 ± 0.4	0.2 ± 0.3	6.3 ± 1.6	121.3	< 0.001
Range	0 - 1	0 - 2	2 - 7		

[1]All planes except supersonic transports (SST).
[2]F value, analysis of variance
[3]Involving physical contact.

Chick Mobility

Gulls are semiprecocial, and the young can stand and walk about as soon as they dry off after hatching. Thereafter chick movement around and away from the nest varies from species to species. In some species, such as Kittiwakes, *Rissa tridactyla,* (Cullen 1957), Brown-hooded Gull, *L. maculipennis,* and Franklin's Gulls, *L. pipixcan* (Burger 1974), the chicks do not normally move from the nest until they are almost ready to fly. Only when disturbed by humans will Franklin's and Brown-headed Gull chicks leave the nest to swim in the water, where they often become entangled or lost in the vegetation. A single walk through an undisturbed Franklin's Gull colony resulted in two of 30 chicks disappearing completely, and nine chicks ending up on the wrong nest (they had been banded previously within a day of hatching). Several pairs ended up with more chicks than they had before the disturbance. Similarly, supernormal broods were noted in a Brown-hooded Gull colony in Argentina disturbed only once during the chick phase (unpub. data). The creation of larger than normal broods places increased energy demands on the parents because they must feed more young. In Franklin's Gulls, broods of over three rarely fledged chicks, and when they did the chicks were so underweight that they died before leaving the vicinity of the colony (Burger 1974). During heavy rain and hail storms, Franklin's Gull parents with more than three chicks were unable to keep them brooded, and chicks died from exposure.

In some species the chicks remain near the nest on their parent's territories until they fledge (Kelp Gull, *L. dominicanus,* Herring Gull); while in others the parents frequently move broods from place to place (Ring-billed Gull, *L. delawarensis,* Evans 1970, Conover and Miller 1978). In ground-nesting gulls the presence of humans appears to increase the distance chicks run from the nest (Hunt 1972), and may result in premature fledging. Although several authors have attributed decreases in reproductive success to this increased mobility, it has not been carefully examined in gulls. Further, the effects of such mobility are difficult to assess as displaced chicks either may quickly return to their nests, or may be killed enroute back, or they may get lost.

Most investigators who are making nest checks pick up chicks to band or weigh them. I examined the effect of human intrusion on chick mobility in Herring Gulls nesting on Clam Island and on nearby Islajo (see Burger 1977) and Carvel Islands (New Jersey) in 1975, 1977 and 1978. I compared the distance banded chicks were located from the nest for chicks that were disturbed (and handled) daily with chicks disturbed weekly (Carvel and Clam Islands; similar bush habitat). All study plots were in the centers of colonies to eliminate edge position effects, and as there were no differences in chick sizes I assumed age differences were minimal (see Ryder 1980). Chicks handled daily moved farther from their nests than those handled weekly (Fig. 5), the largest change in distance moved occurred after 10 days of age.

In order to assess the effect of handling I also compared the movements of chicks picked up daily with those of chicks that were walked by but were not picked up (Clam Island, bush habitat, 1978). In two cases I dropped dye on the chicks (for experimental purposes), but this did not cause them to run. In both experimental procedures, the intruder spent equal time in each study plot; only the handling varied. The response of Herring Gull chicks varied according to the procedure used (Fig. 6). Repeated handling resulted in the chicks

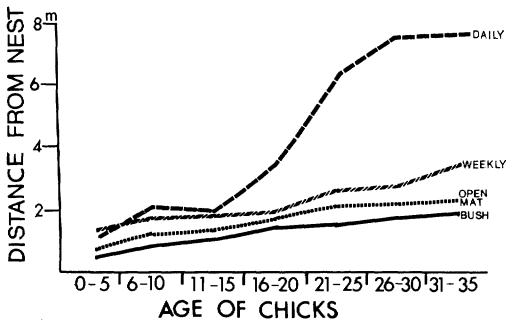

Fig. 5. Location of Herring Gull chicks relative to their nest locations: Daily = chicks were picked up and weighed daily (bush habitat); Weekly = chicks were picked up and weighed weekly (bush habitat); Open mat = chicks from an open *Spartina* mat were observed from afar, and were *not* picked up; Bush = chicks from a bush habitat were observed from afar, and were *not* picked up.

Fig. 6. Distance Herring Gull chicks were found from the nest in the bush habitat. Chicks were located and were then handled (picked up and weighed) or not handled.

running farther from the nest, rather than habituating to the handling. Interestingly, chicks that were not handled did not run when approached until they were older than 20 days, whereas handled chicks ran almost immediately when approached by a human. Some of the chicks that were not handled did not run until they were 30 days old.

To assess the influence of habitat on chick mobility when disturbed by humans, I compared the movements of chicks nesting in bushes with those nesting on a completely open *Spartina alterniflora* mat (on Islajo Island, 1975). In both cases I made all observations from blinds entered from the rear, and I never walked through the study plot after the chicks were banded. All nests in the study plot were synchronous, having been initiated within three days of one another, so I could band all chicks at once. After being in the hide for one hour I recorded the position of all chicks every 10 min. for at least six hours each day (Fig. 5). Under these conditions there were no differences in where chicks normally stood with respect to the nest, and chicks usually remained within 2m of the nest. Figure 5 shows a comparison of chicks completely undisturbed, with those handled daily, and weekly in the bush habitat.

Clearly, the nature and type of disturbance is extremely important, and needs to be described and, if necessary, controlled in all studies of breeding biology, not only those dealing specifically with investigator effects. Chicks that remain within 2m of their nests are unlikely to encounter territorial aggression or outright cannibalism from their neighbors. Further, nesting gulls that are not disturbed remain close to their chicks and are able to defend them from intruders. The difference in mobility between handled and unhandled chicks (exposed to the same human intruder) suggests that the investigator must weigh the advantage to his study of handling chicks against the costs to the bird population in terms of lowered reproductive success.

GENERAL DISCUSSION

In addition to causing actual destruction of eggs, chicks, or adults, human disturbance can cause birds to abandon their nest sites and colonies. In Black-crowned Night Herons (*Nycticorax nycticorax*), visits before or during egg-laying caused abandonment of nests and late-nesting birds did not settle in disturbed areas (Tremblay and Ellison 1979). Double-crested Cormorants (*Phalacrocorax auritus*) were similarly affected (Ellison and Cleary 1978). Such abandonment can be permanent or temporary. Permanent abandonment of nests seems to occur more commonly during the egg-laying phase (Manuwal 1978).

Gulls are particularly vulnerable to human disturbance prior to and during egg-laying. Conover and Miller (1978) found that when Ring-billed Gulls were first settling on the nesting island, they roosted on the water at night. During this stage, the gulls would not land on the colony if humans were present, and left for the remainder of the day if humans entered the colony. Human disturbance during egg-laying resulted in nearby individuals flying up, but the entire colony rose up when adults were being captured. Continued capturing of adults during this stage caused complete desertion of the colony site. Gulls were less wary once incubation began. In my experience, Franklin's Gulls and Laughing Gulls *L. atricilla*, behave similarly. Repeated entering of blinds or censusing of an area prior to egg-laying usually resulted in abandonment of that nesting habitat (particularly if optimal habitat were limited): such abandonments may preclude nesting for that year.

Temporary abandonment of nests and eggs, caused by disturbance often results in egg and chick loss because of thermal stress (Bartholomew *et al.* 1953, Bartholomew and Dawson 1954, Vermeer 1963, Harris 1964, Drent 1967, Hunt 1972), predation (Kury and Gochfeld 1975, Ellison and Cleary 1978) and cannibalism (Harris 1964, Parsons 1971, Hunt and Hunt 1975, 1976). Most investigators working with gulls have noted that cannibalism is the primary cause of mortality (see Parsons 1971) although cannibalism is not an important cause of egg and chick mortality in Franklin's Gull (Burger 1974) and Glaucous-winged Gull, *L. glaucescens* (Gillett *et al.* 1975). Thus temporary removal of adults from eggs and chicks can drastically reduce reproductive success for most gulls.

The effect of the experimenter on gull and tern colonies has been noted in passing by several authors (see Ashmole 1963, Kadlec and Drury 1968, Buckley and Buckley 1972) and most of them have found deceased reproductive success with increased human disturbance (but see Weaver 1970). Hunt (1972) found that hatching success of Herring Gulls was lower in disturbed areas (19-25%) compared to undisturbed areas (43-54%); a difference he attributed to thermal stress when eggs were exposed. He did not find a difference in chick-rearing success. Similarly, Parsons (1975) found no difference in hatching success between an area visited twice daily and one visited every other day. In Glaucous-winged Gulls, however, chick deaths were higher in disturbed plots (27%) compared to undisturbed plots (11%) in 1973; and egg and chick deaths were higher in disturbed (31%) compared to undisturbed (8%) plots in 1972 (Gillett *et al.* 1975). In these two studies the investigator effect was not the principle object of the study. Robert and Ralph (1975) conducted a controlled experiment to examine the effect of the investigator on Western Gulls, *L. occidentalis*. They had six types of disturbances ranging from being disturbed three times each day (30 min. each time) to being disturbed only twice during the entire season (called undisturbed). They found that hatching failure was directly proportional to the amount of disturbance, whereas chick mortality was inversely related to the amount of disturbance. They reasoned that the chicks that were disturbed more often had become habituated to the investigator and so did not run into nearby territories (where they could be killed or eaten). Nonetheless, when they compared the undisturbed plot (visited twice in the season) with all disturbed plots, chick mortality was less in the undisturbed plot. Although disturbed gull chicks run from the nest on their own, and then attempt to return after the disturbance, adult terns lure their chicks from their nests when they are disturbed, and feed them in these new locations (see Veen 1977).

As is apparent from the above discussion, the effects of human disturbances are many and varied. With several years of data on the effects of human disturbance I find that reproductive success is sometimes higher and sometimes lower in completely undisturbed study areas. Although it is easy to demonstrate behavioral differences in attentiveness, aggression rates, and chick mobility, the relationship between these events and reproductive success is less clear, and varies among species. Clearly, the investigator must evaluate how each procedure affects the behavior and reproductive success of the birds he is examining.

SUMMARY

People affect nesting colonies of birds in diverse ways. They can destroy the nests, eggs, or chicks or force birds to abandon their nest sites and colonies. They can keep adults off their chicks and eggs, thus exposing them to temperature stress or predation. The above effects can be lethal to eggs or chicks, and result in immediate and obvious decreases in reproductive success. Many other effects of human disturbance are less obvious, but nonetheless contribute to lowered overall breeding success. Such effects include; decreased incubation and chick attendance, shifts in the mate incubating, earlier and distant movements of chicks, entanglement of chicks in vegetation, increased brood sizes (when several chicks enter the same nest), more frequent aggressive encounters, greater energy expenditures for territorial defense, and attraction of predators to nest sites.

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