

THE BREEDING BEHAVIOR OF THE CASSIN AUKLET

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Until the present time the habits, growth rates, and breeding behavior of the Cassin Auklet (*Ptychoramphus aleutica*) have remained little known. Bent (1919:110-116) compiled the information available up to 1919, but inconsistencies are apparent in the data available to him. Coues (1868:52-53) describes the external characteristics of the Cassin Auklet in his monograph on the Alcidae, and Dawson and Bowles (1909:912-916) give an interesting but brief description of the nocturnal activity of the species. Most other references to Cassin Auklets concern range, occurrences, or numbers found dead on the beach.

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GEOGRAPHIC DISTRIBUTION

Until recently the Cassin Auklet has been considered numerous along the entire Pacific coast of North America from the Aleutians to approximately the 27° parallel of latitude which passes through the middle of Baja California, México. Grinnell (1928:56) gives latitude 27° as the southernmost extent of the breeding area and states that the species is not known in the Gulf of California.

In the northern part of the range, the occurrence of the Cassin Auklet has gradually become less frequent. Gabrielson and Lincoln (1959:496) give extensive mention of its occurrence in Alaska, quoting several authors. They indicate that at the present time the Cassin Auklet cannot be considered abundant anywhere in Alaska.

MATERIALS AND METHODS

Field observations were made on the coasts of southern Oregon and northern California between June 15 and August 31, 1958. The study was continued during the summer from May 18 to August 18, 1959. Further data were collected during January and March, 1960. Castle Rock near Crescent City, California, was visited on several occasions and near the end of the season a colony of about 50 pairs was located.

Martin (1938:260), reporting on Castle Rock, states that he found no Cassin Auklets. I recorded adults sitting on eggs on April 26, 1959, and a juvenile in a burrow in the latter part of August, 1958. A search was made for the auklets on several islands off the southern Oregon coast without success. One dead auklet was found at the summit of Goat Island opposite Harris Beach State Park, Brookings, Oregon.

During October, 1958, 25 artificial burrows with hinged lids and light baffles were constructed of wood. These burrows, approximately four feet long and six inches square, were transported to Castle Rock and partly buried in the soil in the hope that the auklets might utilize them during the next breeding season. Upon visiting Castle Rock again on April 26, 1959, I found that none of the 25 boxes had been utilized by the birds.

On the same day five burrows were opened to reveal two auklets incubating eggs. Further investigations on Castle Rock were discontinued because of the danger in landing on the island and because none of the auklet burrows was sufficiently shallow to observe without great disturbance and certain desertion by the birds.

Through the courtesy of the United States Coast Guard, the week of May 17-24, 1959, was spent on the Farallon Islands, California. The auklet colonies were very extensive with considerable variation in the location of the nests. Because of reconstruction work by the Coast Guard personnel, many of the auklets had been disturbed and slaughtered. The removal of old lumber and building material lying around on the island proved destructive to auklets. On the morning of May 19, 36 suitable burrows containing fresh eggs were staked and marked as observation nests. The same afternoon all but six had been destroyed by the tractor. Some excellent observation nests which I had marked for study were destroyed again the next day when a clean-up crew burned all the stray lumber found lying in the area of the most dense auklet colony. These nests had been observed previously by merely lifting up the ends of the boards.

Additional suitable burrows were sought out and marked on May 20. At this time a number of nests were also located in which pipping or hatching young were measured, weighed, and recorded. On June 18, 1959, I returned to the Farallones to continue my investigations throughout the summer. The records begun in May were continued except in cases in which the eggs had hatched during my absence, leaving no indication as to the age of the chicks. Many new nests were found with eggs in late stages of incubation and more hatching chicks were located. A total of 75 nests was studied from which the information necessary for incubation time, growth rates, and mortality was obtained.

The area around the Coast Guard building proved excellent for night observations on the auklet activity, since the electric lights provided sufficient light to observe with the aid of 7×50 power binoculars the movements and behavior of the birds without disturbing them. Experiments with various colored lights were conducted in other areas with no success. The auklets were able to detect and became wary of white, amber, red, blue, and green light even when the colors were rather dense. The auklets, however, were quite accustomed to the light from the buildings, especially around the powerhouse, which was lighted all night. Approximately 175 hours were spent in night observations during the study.

Observations were made on burrow digging, courtship displays, precopulatory behavior, copulation, territorialism, recognition and greeting, and symbolic display. Auklets' sounds were recorded on tape by placing the microphone near the burrows and by operating the recorder from a distance. An endeavor was made to interpret the sounds and associate them with their actions. Interpretations, however, proved difficult since in the dim light it was often impossible to tell which bird was producing the sounds.

The eggs and chicks were measured and weighed in the field almost every morning at approximately the same hour. Burrows containing eggs were observed daily in order to determine the hatching time. Weights were obtained with a triple-beam balance and measurements were made with vernier calipers, dividers, and a centimeter rule. When the chicks were more than 30 days old it was necessary to mark them as they often left their burrows at night for exercise and would occasionally be found in neighboring burrows. At this age colored plastic tape was placed around the tarsi of the young birds.

Auklets exhibit no external sexual dimorphism. Consequently, it proved impossible to distinguish between male and female in the field.

Most of the auklets had left the island by the middle of August and all of those included in my study had left the nesting area by the morning of August 18, 1959,

when I terminated the summer observations. Further observations were made on auklet activity from January 12 to 16, 1960, and from March 17 to 23, 1960, at which time many of the previous observations on mating activity were confirmed or reinterpreted.

ENVIRONMENT OF THE BREEDING GROUNDS

Cassin Auklets usually breed on rocky off-shore islands, especially where soft soils have accumulated and grasses have taken hold. Burrows vary from two to five feet deep, but where the soil is thin or absent, any hole or crevice between the rocks is substituted for a burrow. On Castle Rock the auklets burrowed deeply into the clay soils under rank tufts of grass. The burrows on this island were also variously branched with blind alleys, or with frequent curves or spirals.



FIG. 1. Burrows of Cassin Auklets (*Ptychoramphus aleutica*) extended up the slopes of Light-house Hill and were found on the floor of a cave as indicated by the pointer.

On the South East Farallon Islands, which are about 100 acres in area and which lie 28 miles west of the Golden Gate, San Francisco, California, the colonies were very concentrated in the sodded areas and scattered elsewhere over the islands where the rocks were suitable. Besides using burrows in soil and cracks in and under rocks, the auklets were also found burrowed into the guano in Brandt Cormorant (*Phalacrocorax penicillatus*) territory, under piles of driftwood and lumber or debris from ruined buildings, in burrows under the occupied buildings of the Light Station and on the floors and recessed ledges of caves. Nests were found from a few yards from the spray zone to the highest parts of the islands about 300 feet above sea level (fig. 1).

Air and water temperatures on the Farallon Islands vary little during the year. Foggy weather is common and high winds from the northwest prevail during the clear periods. The annual precipitation according to the weather records at the Light Station is approximately 9 to 10 inches, most of which falls between late December and April. Average sea surface temperatures from June to August were 50° F. Temperature readings of the sea on January 12, 1960, were 49.1° F., and on March 20, 1960, were 50° F. Air temperatures also showed little variation. The mean temperatures for July, 1959, showed a low of 54.0° F. and a high of 57.5° F. Those for January, 1960, showed a low of 49.7° F. and a high of 54.1° F. The lowest temperature, 43.0° F., was recorded in January and the highest, 76° F., was recorded in October.

On January 12 and 13, 1960, it was noted that the auklet activity on land was greatly inhibited during heavy showers of rain. At this time some burrows were temporarily flooded and the auklets returned to the open sea earlier than on the clear nights of January 14 and 15. However, I believe that the first rains may influence the return of the auklets to land. The first rain after the dry season was recorded on December 23 and 24. The auklets were heard on the island by Coast Guard personnel soon after the rain. Burrowing conditions are obviously facilitated when the soil is damp.

The predominant vegetation, including the Farallon weed (*Baeria maritima*), a succulent sand spurrey (*Lepigonum macrothecum*), and two grasses (*Hordeum murinum* and *Polypogon* sp.), is green until the end of May when the plants begin to dry out. The Farallon weed dies completely, leaving only entangled stems in the areas of soft soil. The roots of the weeds and grass serve to hold the soft soil together, thus facilitating extensive burrowing by the Cassin Auklets.

INTERSPECIFIC RELATIONSHIPS

Petrels and auklets require similar nesting sites, but there is little apparent relationship between the two species. Petrels darting about often dived close to resting auklets, causing them to scatter in alarm. In a few instances petrels were seen to utilize the recesses of vacated auklet burrows, but the numerous smaller cavities among the rocks and walls on the Farallones seemed to be preferred by the petrels. Rock Wrens (*Salpinctes obsoletus*) were often seen flitting in and out of auklet burrows in search of carabid and tenebrionid beetle larvae.

Gulls interfered with the auklets considerably. Auklets which nested in gull territory suffered great losses, and adult auklets landing clumsily at night near a gull were almost sure to be killed. From the examination of several dead auklets in gull territory it was found that the chief cause of death was from pecking blows to the skull. Chicks and juvenal auklets were often seen being eaten by gulls and several were seen being carried off alive. Early each morning several gulls paraded the auklet territory peering into shallow burrows apparently in search of auklets. Anthony (1906:135-136) says, "I have seen a Western Gull pull a Cassin's Auklet from a somewhat more shallow burrow than usual and swallow it with the same gusto and apparent relish with which it bolted the egg a moment later." My observations were that the gulls pecked the auklets apart before swallowing the pieces. Juvenal Pigeon Guillemots (*Cepphus columba*), while on the water, were also seen being attacked by the gulls.

European rabbits, the only species of mammal on the island, do not appear to disturb the auklets to any degree. At night the auklets merely move aside to let the rabbits go by, then immediately continue their activity. Loomis (1896:355) observed an auklet sharing its apartment with two rabbits.

CALLS AND COMMUNICATION

Those who have ventured into auklet territory at night during the breeding season are aware that these peculiar birds, although evasive in their nocturnal habits, are far from quiet. Dawson and Bowles (1909:915) have aptly described the auklet chorus as reminding one of a frog pond in full cry or of the squealing of pigs. Also, there is a similar tendency for the sounds to begin simultaneously. Often the entire auklet colony may be silent for fifteen minutes or more, and then in one corner an individual will become vocal. Within seconds the whole area resounds with their "kreeking." While producing the sounds, the head extends forward, the throat puffs considerably, and the whole body vibrates.



FIG. 2. An adult auklet poses against a clump of Farallon weed (*Baeria maritima*). The birds were easily held in the beam of a flashlight to facilitate photographing them at night.

At least ten variations of the auklet sounds were noted during the many hours spent in nightly observations. When arriving from the sea, the auklets flop clumsily to the ground within a yard or two of their burrow entrance, scamper along the ground, half hopping, half running, often uttering short, clipped *krick* sounds as they disappear into their holes. When the incubating mate is present a series of guttural *ker-chuck—ker-chuck* sounds are emitted, apparently as a greeting from the incubating bird. Silence usually follows or a sipping sound may be detected by listening close to the burrow. These sipping sounds were also heard at times of feeding from nests far back in a cave.

Sounds made by the adult birds during mating, greeting, and social activities are variations of the basic katydid or cricket-like chirring or *kreek-kreek-kreek-kreek*,

which is usually warbled slightly on the *ree* syllable. The *kreek* sound varies in duration, pitch and frequency. During the full chorus sudden changes in rhythm occur. A repetitious *krick-i-er*, may switch to a *kreeka*, *kreeka*, to *kut-i-er-kut-i-er-kut-i-er* or to a nontrilled *kreer-kut-kreer-kut* or *kreek-ut-kut-ut*. This last sound is frequently reversed to a *kut-reeah-kut-reeah*, a variation not unlike the sounds of the Killdeer (*Charadrius vociferus*). While sitting or circling about on a rock, auklet pairs were heard to utter mutual trilled and warbled *kreerr-er*, *kreerr-er* sounds in between considerable twittering which I am unable to describe. Fights between two birds initiated a growled chirring, or *krrr*, *krr*, *kr*. The warning call is a loud *kreer*.

During January observations most of the sounds were made from the burrows. In many instances only one bird was present in the burrow but all were actively contributing to the *kreek-i-er* chorus. In March, and later in the season, the sounds were most vigorous between midnight and dawn.

COURTSHIP AND MATING

Cassin Auklets arrived at their breeding grounds on the Farallon Islands as early as the last week in December, 1959, and by the first week in January, 1960, they were present at night in large numbers.

The presence of the auklets on the Farallones during the winter has been noted by at least three authors but has been ignored in more recent literature. Heerman (1859:75) states that the Cassin Auklets abound on these islands during the winter but he states that he did not find them present in the spring. Gruber (1884:171) indicates that the auklets are occasionally present in winter on the Farallones and Bryant (1888:28) records that the auklets came in great numbers on January 14, 1887. Observations during the middle of January indicate that these early arriving birds were beginning mating and nesting activities. Although no eggs were found at this time, the auklets were busy "kreeking," bowing, scratching burrows, or searching for suitable burrow sites. Old burrows were repaired by many birds, and new ones were begun by a few. Very little activity above ground was observed in January and most birds stayed only three or four hours after their arrival, which was about one and a half hours after sunset.

Weed plucking in certain areas and pecking at the bare ground were conspicuous and some of the plucked material was actually taken into the burrows and strewn along their entire length. The significance of weed pulling and ground pecking is not clear since the eggs are laid on bare soil, but it is thought that this habit may be a response to the nest-building drive. It does not appear to be aggressive behavior comparable to grass pulling in gulls. Several pairs of birds were seen to search around boulders for new burrowing sites, frequently pecking the ground or plucking weeds as they proceeded. The urge to burrow in one pair seemed so great that they vigorously scratched the soil in many places with their feet.

Mutual displays included recognition and greeting movements, a type of circling, or an about-facing habit, head bobbing and bowing, head wagging, wing raising, and passing. Recognition and greeting ceremonies were frequently brief and sometimes absent. At times when two birds were fighting, the arrival of a mate would usually end the squabble with no displaying. On other occasions, especially early in the night activity, the incoming bird was welcomed with side-stepping, billing, nibbling of the facial and neck feathers and with *krrr-krrr-krrr*, or *chirr-chirr-chirr* sounds repeated over and over at intermittent intervals. Circling is characterized by about-facing or by weak side-stepping partway around the mate and is often accompanied by pauses, wing raising or quick steps to a facing or mounting position. In wing raising only one wing is slightly

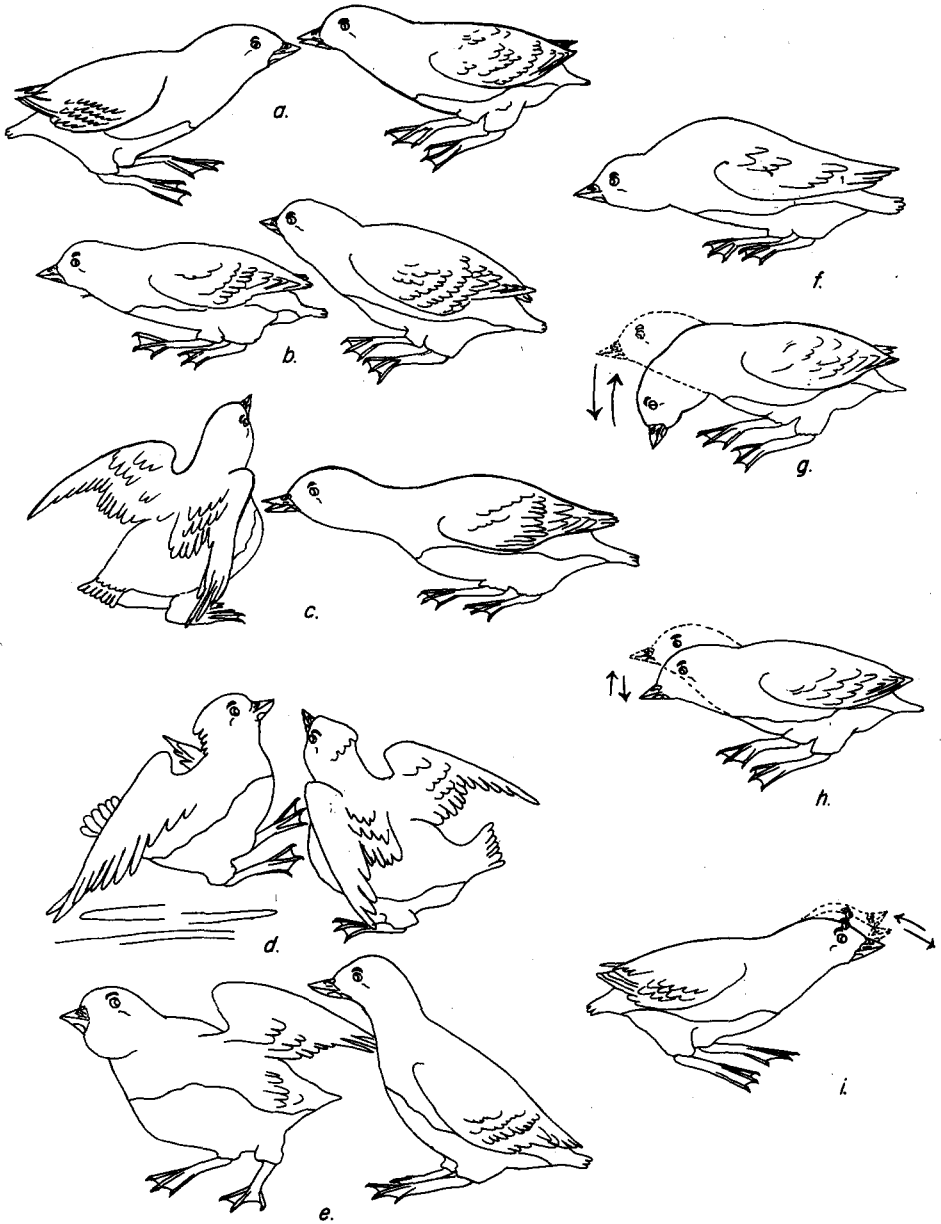


FIG. 3. Displays of the auklets. a, Billing, much time was spent by mating birds nibbling each other's bill and the feathers at the base of the bill; b, passing, one bird of a pair pauses while the other waddles past; c, jabbing, a sudden forward peck toward a neighboring bird; d, face-to-face combat, appears to be a real fight in cock fashion; e, wing-raising, a display seen between pairs of birds, the wing is raised toward the mate; f, threat posture, the back is humped and the bird moves toward an opponent; g, head bobbing; h, head bobbing, a more rapid, less precise movement of the head than in head bowing; i, head waggle, a side-to-side motion.

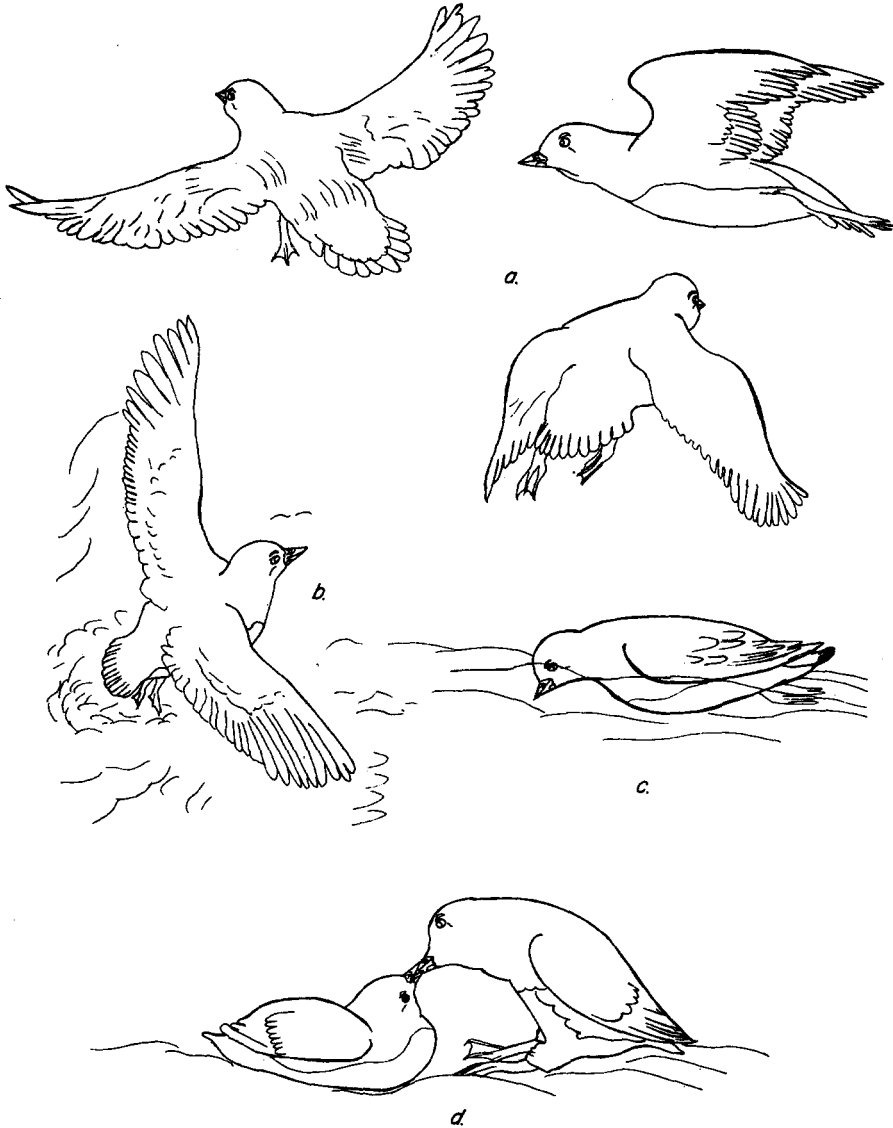


FIG. 4. a, Three positions of the wings during flight (made from photographs); b, wing stretching, a motion seen often while the birds are on water, especially after periods of diving; c, bill dipping, a common habit among most of the alcids; d, feeding posture, the young bird sits while the parent humps and regurgitates food that the young sips from the parent's bill.

spread in a horizontal position toward the mate. Among the commonest habits are head bobbing, bowing and wagging. The bowing is not a precise prolonged bow, as is demonstrated by murres, but a quick forward tilting of the head. In bobbing the whole neck moves quickly up and down. In wagging the head and neck are moved from side to side. Bobbing and wagging were seen frequently in pairs after the *kreek-i-er* sounds were emitted. Passing is displayed when one bird of a pair, after sitting for a period,

moves ahead of its mate, half hopping and half running. The second bird follows and passes the former, often pausing immediately in front. Passing is often continued for five or six meters and most often ends with one of the pair quickly about-facing to bill with its mate, or with both birds flying a small circle and returning to the original starting place near the burrow site. Some of these motions are illustrated in figures 3 and 4.

Forward jabbing and pecking thrusts are commonly displayed against intruding birds. On one occasion I observed four birds peacefully occupying a position on the same rock. Present one pair of the auklets left and thereafter the other pair vigorously defended the position from further intrusion. Apparently a definite area is not defended.

On May 20, 1959, the activity of more than fifty birds was clearly seen in the light from the powerhouse. On this occasion one pair of birds was seen to engage in copulation which lasted for approximately 30 seconds. The sexual act which took place on the rock was preceded by considerable bowing, head wagging, billing antics, twittering and intermittent "kreeking." It was impossible to isolate the particular sound produced by these two birds from the constant din from all the other auklets in the area. Following the billing and calling, one of the pair squatted while the other, apparently the male, waddled up to its mate with its body humped, tail erect, and head pointed downward at about a 45 degree angle. Wing spreading and back stepping preceded the act of coition. After dismounting, both birds rustled their feathers, stretched by flapping the wings, settled down face-to-face, and began more calling, billing and wagging their heads from side-to-side. The billing antics seen in many other pairs of birds seem to be chiefly aimed at the white patch at the base of the lower mandible although nibbling of the bill and tips of the facial feathers is a frequent habit.

Similar behavior without copulation was observed between pairs of birds during the season. The acts of courtship in these instances were usually followed by periods of stretching and preening. This preening is undoubtedly the same as "substitute preening" as described by Tinbergen (1939:225-226) and as mentioned by Storer (1952:149) in the genus *Cepphus*. Thoresen and Booth (1958:10) have also described similar motions in the Pigeon Guillemot during mating behavior. The actions in the auklet, however, seem to be less pronounced than those seen in the Pigeon Guillemot and the events occur in more rapid sequence.

NESTS AND TERRITORIES

Storer (1952:142-146) has pointed out that guillemots demonstrate considerable versatility in their choice of nesting sites. The auklets demonstrate the same versatility. As with the guillemots the prime requirement for a nesting site is a roof or shelter from gulls and other predators.

Nesting periods are staggered, some birds beginning early, others later in the year. Most auklets begin earlier than the majority of other species of sea birds and late nesting auklets are apt to desert their egg at the slightest disturbance. Dawson and Bowles (1909:912) give the nesting season as being from April to June. Dawson (1911:174) records that fresh eggs were the rule from May 20 to June 3, 1911. Bent (1919:110-116) states that the breeding season is prolonged from April to November but records eggs on an island off Lower California early in March. Howell, in notes sent to Bent (1919:111), observed that early in June, 1910, on the Los Coronados Islands, in 50 nests he examined, all contained eggs in various stages except three which had small young: On June 30, 1913, the order was reversed. There were only three eggs and the remainder of the nests had young in all stages.

Further examples of nesting times are given in the literature. Heath (1915:34) quotes the Alaskan natives as indicating that the auklets arrive on Forrester Island about March 1. Stephens (1921:96-97) reporting from the Coronados Islands, México, noted that on March 5, 1921, auklet burrows had been cleaned out, but no birds were present in the burrows. Smith (1934:171) notes fresh eggs on the Farallones on August 17, 1933.

On January 12, 1960, according to my own observations, and as early as the last week of December, 1959, according to the Coast Guard personnel stationed on the Farallones, the auklets were already engaged in the cleaning of old and the excavating of new burrows. Bryant (1888:29) observed that the auklets did not make burrows on the Farallon Islands but laid in natural cavities among the rocks. This is far from the truth at the present time, for auklet holes honeycomb all areas where soft soil is available, while the natural cavities among the rocks are still inhabited. Bryant (1888:28-29) also states that the auklets came in great numbers on January 14, 1887, and that eggs were found as late as November 20, 1886.

Although auklet burrows were most dense in the sodded depressions between rocky areas, no definable individual colonies could be distinguished. In the dense areas burrow entrances were often only a few inches apart, although no tunnels were found that intersected with each other.

Excavation of burrows takes place with no little ceremony, and both birds take part in the digging. On one occasion I observed two birds actively taking turns at scratching out the beginning of a new burrow. The beginning of the burrow on flat ground is started by scratching in all directions. The birds have needle-sharp claws and digging is accomplished with the expenditure of considerable energy and skill. The feet scratch alternately, scattering the soil to a distance of a meter or more. After a depression is made in the ground the birds begin to dig on one side until a cavity results. Due to the many pauses to run, hop, threat, bow, and *kreek* to partners, the digging proceeds slowly. Usually only two or three inches of depth are accomplished in one night. Two burrows started on the night of January 18 were still being excavated on March 17, at which time they had progressed to a length of approximately three feet. The auklets seem to prefer some solid material under which to burrow and most burrows begin at the base of a rock, board, log, the roots of vegetation, or the side of a bank. The reason for this is obviously mechanical. The tunnels formed may be straight or variously curved to spiralled. Blind side branches are also found in the burrows, although this is the exception rather than the rule on the Farallones. Depending on the location and the soil condition, burrows varied from 18 inches to about 4 feet in length. On Castle Rock, Del Norte County, California, the burrows tended to be deeper and more spiralled in the heavily sodded banks. In shallow soils on the Farallones the burrows ran parallel to the surface at a depth of about 3 to 10 inches. In many instances it was possible to locate the end of the burrow without disturbing the natural entrance, and I found that by digging down to the burrow's end and then blocking my excavation with a small rock, I had easy access for observation purposes.

During the approximately 175 hours spent in night observation in a position where 20 or more pairs of birds could be seen with reasonable clarity, several different types of social displays were evident. Early in the year the activities were primarily concerned with mating and burrow defense. Later in the season, the displays seemed more recreational and for the preservation of the pair bond.

Among actively displaying birds, fighting is commonly demonstrated. These fights were seen to vary in intensity from threat postures and jabbing, to face-to-face combat.

In threat posture the auklets may or may not be in full stance. The position is recognized when one bird makes a step toward its opponent with the back humped and bill forward. The opponent usually moves. Jabbing, or forward pecking movements, are a more active threat. This is seen frequently when a second or third bird tries to mount an occupied perch. The perched bird makes several quick jabs toward the intruder, causing it to retreat. If the intruder fails to retreat, actual contact pecking results and the intruder is pushed off the perch. This type of fighting often results in both birds leaving the perch to continue their pursuit among the weeds. On the ground, chases are characterized by running or hopping in spurts with the head stretched forward, or by flying a few feet at a time. I have seen such chases result in the pursued bird returning to the original perch to gain the mastery and reverse the roles in the procedure.

Face-to-face combat is not uncommon among auklets. In this the opponents face each other with tails erect, wings partly spread and head feathers ruffled. Their heads waggle briefly and contact is made by leaping at each other like roosters in a cock fight. Combat ends when one bird turns and runs. The stimulus for this "cock fighting" is not clear. It is certain that it is not strictly territorial, since the chases and fighting occurred over wide areas beyond the limits of many burrow entrances.

Other chases involving up to a dozen birds all switching roles from one moment to the next were interpreted as social or recreational display. This behavior I have called "tagging." Wing coverts and tail feathers of one auklet were often caught with the bill of another bird during tagging games, and along with the tagging, "leap-frogging" was demonstrated actively. Leap-frogging occurred when a pursued bird suddenly stopped and turned on its pursuer which escaped by jumping over its opponent with the aid of its wings. I have seen two birds leap each other three times in succession, each turning upon the other to give chase or to tag.

Besides tagging and leap-frogging, a sport of dodging in and out of the weeds and popping in and out of burrows was indulged in by several birds at a time. In these activities no bodily contact was observed. The object of the display seemed merely to keep out of the way of one another.

The social activities and the mild fighting observed in auklets on land remind one of the activities displayed by Pigeon Guillemots on water during the otherwise idle hours of the day as described in considerable detail by Storer (1952:147) and Thoresen and Booth (1958:33). Auklets at sea show no evidence of social behavior. During the daylight hours I observed auklets at sea about two miles from the Farallon Islands and rather than floating in compact rafts they were widely scattered. The individual birds skittered over the surface of the water, dived or took to flight as the ship approached.

INCUBATION AND HATCHING OF EGGS

Although auklet activity was considerable in January of 1960, no fresh eggs were found. Several unhatched eggs from the previous season were found that had been pushed out of the burrows by the birds during the cleaning process.

Van Rossem (1939:443) noted that Cassin Auklets were incubating eggs on February 2, 1932, on San Benitos Island, Baja California. This is by far the earliest egg date for this species.

Since only one egg is laid, determination of the incubation period was purely by the chance of finding freshly laid eggs and tracing them until they hatched. I was never sure of the exact age of the eggs when found. Two eggs were incubated for 37 days after I discovered them, and both hatched the same day. Therefore, the only conclusion

that can be drawn at the present time is that the incubation period for the Cassin Auklet is at least 37 days. Information in the literature on the incubation period of auklets indicates two different times, both of which are cited in Bent (1919). Bent quotes Emerson as giving an incubation period of 21 days and Littlejohn as giving an incubation period of 30 days. Apparently these records are merely guesses. Incubating birds move the eggs to various positions under their body, and several auklets were seen to hold the egg under a wing.

Hatching of the eggs occurs after two or three days from the beginning of pipping. A few eggs were seen to hatch within 24 hours after the first signs of pipping, but most took longer. One egg which had been pipped for about 30 hours was found deserted by the adult early one morning. The egg felt quite cold and was taken indoors, wrapped in wool and set in a warm place. The chick hatched six hours later. The same evening just before the arrival time of the adults this newly hatched chick was replaced in the burrow from which it was taken. The next morning an adult bird was with the chick, which now appeared healthy and normal. The chick was alone again the next day but was raised to the age of 35 days. Its gain in weight was only half that of other chicks, and the bird was found dead on the thirty-sixth day.

Another cold day-old chick was taken indoors and kept warm for the day and replaced in the burrow in the evening. The adults returned and raised the chick normally. Apparently the adults normally stay with the chick during the day until it is three or four days old at which stage the chick is able to maintain its own body temperature level and remain alone in the burrow.

DEVELOPMENT OF THE YOUNG

Hatching takes place early in the morning and the precocial auklet chicks hatch with a full coat of soft down. The eyes are blackish-brown. The color of the down varies from black to a dark purplish-gray dorsally and from neutral gray to pale purplish-gray or pallid neutral gray ventrally. An area immediately around the eyes tends to be free from down. The frail legs and feet are pink and the toes tipped with black claws.

Tables 1 and 2 indicate growth in auklet chicks by daily measurements of various body parts, and figures 5 to 7 show young auklets at different ages.

Gabrielson and Lincoln (1959:496) have indicated that pinfeathers begin to show at the base of the down when the chick is but two or three days old. However, 10- to 12-day-old chicks are still quite small, soft, and downy and when compared to many other species may easily be mistaken for two- or three-day-old chicks. The legs and feet have changed from pink to blackish-gray with a bluish cast to the upper toes and tarsi by the tenth day. The first signs of the pinfeathers appear between the twelfth and sixteenth day after hatching. These are first evident on the belly, sides, the dorsal midline and on the wings. By the eighteenth day they are also evident on the head and neck.

On the twentieth to twenty-third day the wing primaries are rapidly developing, and the belly coverts are conspicuously white under the thinning down. The juvenal plumage is visible by 30 days when most of the down is replaced with feathers, but patches of down may adhere to the nape and rump until the forty-second day.

The tail first appears about the fourteenth day as a downy tuft. By the eighteenth day the shafts of the rectrices are 1.0 cm. in length and gradually increase to approximately 4.0 cm. before the young auklet leaves the burrow.

The age of the young birds leaving the nest naturally varied from 41 days to 50 days. Of 17 birds recorded, two left on the forty-first day, one on the forty-second, three on the forty-third, two on the forty-fourth, three on the forty-fifth, two each on

TABLE 1
WEIGHT OF YOUNG CASSIN AUKLETS

Age in days	Number of specimens	Average weight (gm.)	Range
0	11	17.81	13.0- 20.0
1	13	19.31	17.0- 22.6
2	13	21.17	18.2- 24.3
3	8	26.24	21.5- 29.5
4	10	26.55	21.5- 31.0
5	10	30.74	26.5- 34.0
6	10	35.33	29.5- 39.3
7	7	41.60	32.5- 49.5
8	7	44.90	39.5- 53.5
9	10	49.69	45.4- 55.3
10	10	53.37	45.3- 58.9
11	9	61.35	53.0- 83.1
12	9	62.40	50.5- 76.3
13	8	72.33	48.7- 86.0
14	7	78.15	60.1-100.0
15	10	84.08	60.5- 98.0
16	11	86.12	58.6-100.0
17	9	94.51	61.4-113.8
18	9	96.04	62.8-109.5
19	9	101.82	70.0-128.0
20	10	104.42	70.6-126.3
21	9	114.95	93.8-138.6
22	9	116.74	93.2-140.8
23	9	120.24	95.0-148.0
24	8	125.61	105.2-147.5
25	9	126.04	101.4-152.5
26	10	135.44	117.6-163.3
27	11	135.63	105.2-162.0
28	9	137.94	119.0-153.0
29	10	140.16	115.5-161.8
30	9	139.46	119.0-159.0
31	11	141.42	103.0-165.0
32	11	143.30	110.0-170.0
33	11	148.56	117.5-171.0
34	11	151.31	111.0-182.0
35	11	153.58	123.3-172.5
36	10	147.77	106.5-165.5
37	12	148.04	102.0-165.0
38	12	153.45	107.5-171.0
39	12	151.86	132.5-174.6
40	11	151.78	125.0-170.0
41	11	152.16	122.3-165.0
42	8	150.06	121.0-162.0
43	9	148.97	135.0-168.0
44	6	147.31	134.0-163.5
45	3	155.33	149.0-162.8
46	3	134.46	125.8-146.5
47	2	124.25	121.5-127.0
48	1	115.50	.....
49	1	117.50	.....

TABLE 2

AVERAGE MEASUREMENTS OF CHICKS OF CASSIN AUKLETS¹

Age in days	Body length	Culmen	Tarsus	Closed wing	Extent	Tail
1	9.52	0.97	1.66	1.85	10.20 (1)	.....
2	10.28	1.04	1.74	2.04	10.25 (2)	.....
3	10.82	1.08	1.79	2.11	.....	.....
4	11.09	1.09	1.82	2.17	12.0 (1)	.....
5	11.45	1.12	1.89	2.28	.....	.....
6	12.10	1.14	1.92	2.46	11.88 (4)	.....
7	12.33	1.18	1.99	2.47	.....	.....
8	12.84	1.19	2.00	2.58	13.4 (4)	.....
9	12.92	1.21	2.11	2.70	13.25 (2)	.....
10	13.44	1.26	2.20	2.85	14.70 (3)	.....
11	14.05	1.29	2.24	3.08	14.0 (1)	.....
12	14.40	1.30	2.26	3.15	16.6 (3)	.....
13	14.75	1.36	2.29	3.55	16.75 (2)	.....
14	15.14	1.37	2.29	3.85	17.1 (3)	.....
15	15.46	1.39	2.32	3.85	19.8 (5)	.....
16	16.06	1.44	2.38	4.28	18.75 (2)	.....
17	16.35	1.46	2.42	4.57	23.7 (7)	.....
18	16.79	1.47	2.47	4.99	25.5 (3)	..... (1)
19	17.09	1.51	2.47	5.20	24.40 (4)	..... (2)
20	17.48	1.54	2.49	5.31	25.3 (5)	1.15 (2)
21	17.83	1.56	2.51	5.78	25.90 (5)	1.37 (4)
22	18.17	1.56	2.53	5.94	27.30 (3)	.....
23	18.40	1.59	2.55	6.44	28.30 (5)	1.3 (3)
24	18.84	1.61	2.59	6.75	30.62 (4)	1.55 (3)
25	18.87	1.63	2.62	7.07	.....	1.15 (6)
26	19.02	1.64	2.64	7.15	31.60 (5)	1.13 (10)
27	19.33	1.66	2.66	7.81	32.00 (6)	1.55 (10)
28	19.56	1.68	2.66	8.17	32.75 (4)	1.55 (10)
29	19.81	1.68	2.68	8.22	35.00 (6)	1.59 (10)
30	19.94	1.69	2.68	8.68	36.00 (2)	1.85
31	19.99	1.70	2.69	8.75	36.00 (6)	1.89
32	20.05	1.71	2.71	8.96	37.40 (5)	2.12
33	20.50	1.74	2.72	9.38	38.25 (4)	2.28
34	20.53	1.75	2.72	9.58	38.50 (4)	2.54
35	20.72	1.75	2.72	9.79	38.58 (6)	2.63
36	20.81	1.77	2.73	10.17	40.00 (2)	2.86
37	21.16	1.78	2.74	10.51	38.66 (6)	3.10
38	21.27	1.79	2.74	10.59	40.80 (5)	3.20
39	21.34	1.79	2.74	10.95	41.0 (3)	3.34
40	21.54	1.80	2.74	11.05	40.33 (3)	3.50
41	21.59	1.80	2.74	11.19	42.25 (4)	3.59
42	21.69	1.80	2.75	11.20	41.00 (3)	3.64
43	21.73	1.83	2.75	11.29	41.00 (4)	3.72
44	21.85	1.87	2.76	11.50	41.60 (5)	3.81
45	21.76	1.81	2.73	11.63	42.10	3.83
46	22.03	1.87	2.79	11.57	42.65	3.90
47	22.35	1.88	2.78	11.65	43.00	3.95
48	22.30	1.85	2.75	11.80	44.00	3.95
49	22.30	1.85	2.75	11.80	44.00	4.00

¹ The measurements are in centimeters. The number of specimens is the same as in table 1 except as indicated by the numbers in parentheses.

the forty-sixth and forty-seventh days, and one each on the forty-eighth and fiftieth days.

Tarsal length expressed as percentages of the body lengths for various ages are as follows: 1 day, 17.5 per cent; 12 days, 15 per cent; 30 days, 13 per cent; and 49 days, 12.3 per cent.

Juveniles in their first plumage can be distinguished from freshly molted adults by their eyes, which are blackish-brown in color instead of white, as in the older birds. Young adults are often observed with a blackish-brown mottling in the eye. Gabrielson

TABLE 3

MEASUREMENTS IN CENTIMETERS OF 13 FIRST-DAY CHICKS COMPARED WITH 21 ADULTS

	Chicks		Per cent of adult
	Average	Range	
Body length.	9.52	8.5 - 11.0	41.44
Culmen	0.97	0.9 - 1.1	50.52
Tarsus	1.66	1.55 - 1.73	62.48
Closed wing	1.85	1.5 - 2.1	14.50
Extent	10.20	(1 specimen only)	23.00

and Lincoln (1959:496) record that the wings and tail are browner in the young birds. This statement is in error, since the wings and tail feathers of older adults are usually considerably browner, even buffy brown, than the blackish-gray of young and freshly molted birds. During the month of August, 1959, several auklets were seen at sea which had lost the ability to fly because of badly worn and frayed wing and tail feathers. During this stage they were limited to the water until new feathers replaced the old.

The weights of 19 live adults, all recorded between 8 and 12 o'clock each morning,



FIG. 5. A juvenal auklet 35 days of age. Down remains around the neck and rump.

ranged from 152.50 grams to 200.00 grams, with a mean of 172.64 grams. Cloacal temperatures of five birds, measured with a clinical thermometer, averaged 106.5° F. with a range between 105.0 and 107.2° F.

NESTING SUCCESS AND MORTALITY OF THE YOUNG

Of the 75 nests studied only 26.6 per cent raised young to the fledging stage. This means that the total mortality of all eggs laid was 73.4 per cent in the study area. The highest mortality, 33.3 per cent, occurred in the egg stage through desertion by the adults. The cause for most desertions was undoubtedly due to my intrusion. Cracked and infertile eggs accounted for 5.3 per cent of the failures, and 12.0 per cent were lost when burrows caved in by wind erosion. During the process of pipping and hatching, 8.0 per cent died, and 14.8 per cent died or disappeared at later stages of development.



FIG. 6. A one-day-old chick exposed in its nest under a pile of driftwood.

The mortality among the chicks which hatched successfully was 35.5 per cent. Three of these lost chicks were seen being devoured by gulls, two died of starvation, and six unaccountably disappeared from their burrows before the fledging stage.

Factors leading to mortality of auklets in areas of the island other than where the 75 nests were located varied. In areas where Western Gulls (*Larus occidentalis*) nested, many young auklets were killed by the gulls during flight exercises. Some died by flying clumsily into buildings and a larger number died by carbon monoxide poisoning near the exhaust outlets of the light station powerhouse. In one week 76 auklets, mostly juveniles, were removed from around one exhaust well. The warmth apparently attracted them and they died in sleeping positions.

FOOD AND FEEDING OF THE YOUNG

Observations on the methods of feeding the young were for the most part carried on by using flash photography inside a cave, where auklets nested in depressions along

the sides of the cave. The arrival of the adults in the cave entrance could easily be detected by the sound of their wings. Following a short silence, during which the birds made their way toward their waiting chick, a clicking sound made by the snapping of the bill was heard. This bill snapping was a signal to the young to begin immediately a constant "chirring" which I have interpreted as location and begging calls. Obviously the birds do not see in total darkness. On several occasions the incoming adults scrambled over my legs and between my arm and body as if I were nothing more than another rock in their path. The bill snapping of the adult and the location calls of the young therefore serve as a means of guidance in the total darkness, as well as evoking the feeding responses. Location of the young in short burrows would not present navigation problems.



FIG. 7. An 11-day-old chick obviously very full of food from the previous nocturnal feeding. The foot webbing has turned dark, while the upper surfaces of the legs and toes now have the characteristic bluish-gray appearance.

Once the parent bird is in contact with the chick, a choking and sipping sound mingled with intermittent twittering indicates that the transfer of food from the parent into the mouth of the chick is taking place. Feeding continues by both parents as long as the young bird continues to beg or as long as the supply of food remains.

Adult auklets arriving from the sea during the incubation and nesting periods regurgitated food material if they were caught or molested. This behavior enabled observation of the food habits of the auklets. Two main types of food were noted. The predominant type consisted entirely of inch-long reddish-orange shrimp identified as euphausiids, commonly referred to as "whale food," while the second type consisted of lanceolate, semi-transparent, white fish with tiny black eyes. This food looked very much like the small, immature fish commonly called "whitebait" in some regions. The material was so well broken up that positive identification was impossible.

NEST SANITATION

The occupied parts of auklet burrows are kept relatively free from fecal material. The birds defecate near the entrance of the burrow and direct the fluid material toward the opening of the burrow. Occupied burrows, therefore, can readily be recognized by the coating of pinkish deposits marking the burrow entrances.

THE FIRST FLIGHTS

Wing exercise begins on the thirtieth to the thirty-fifth day after hatching. Soon after dusk the young birds are seen near the burrow entrances stretching and wing exercising for extended periods. Between periods of exercise they return to the confines of their holes.

At 40 days of age the juveniles begin jumping into the air and running along the ground for several yards in attempts to become air-borne. The first flights are short, up to 10 to 15 meters, and usually end in clumsy crashes which flip the birds head-over-tail. Eventually they become more aware of their "landing gear." This clumsiness, and the fact that bright light dazzles them, is responsible for the death of many birds when they fly into buildings.

FLIGHT OF THE ADULTS

Auklets flying through a measured distance between buildings were timed and their speed calculated to be approximately 45 miles per hour. This speed was characteristic of their flight as they approached the nesting area in the evening. Short flights during the night were made at considerably slower speeds.

Many of the alcids tend to be brachypterous in varying degrees, and often have difficulty in becoming air-borne. The auklets exhibit no sign of being brachypterous and are able to take flight from ground level or from the water surface almost without hesitation. The posteriorly-directed feet are used along with the tail for assistance in flight, but they seem less dependent upon their legs than do the murrelets and guillemots.

When released from the burrow in the daytime, adult auklets fly swiftly in a zig-zag fashion out to sea. They fly low over the ground and continue at a low level once the water's edge is reached. The zig-zag pattern may stem from the sudden confusion of the daylight as compared to the dark burrows, or it may be a means of avoiding the possibility of being followed by enemies. Once far out over the water's surface the auklets are safe from attack from above since they are expert divers and swim under water with great agility. In swimming under water the feet act as rudders and the wings, which are held almost at right angles with the primaries directed back parallel to the body, beat rhythmically, propelling the bird rapidly.

DEPARTURE CEREMONIES

During March, peculiar patterns of display were noted in pairs of birds preparing to leave the island just before dawn. At this time the auklet activity was at its height for about two hours before daybreak. Pairs of birds began leaving the island about one hour before dawn and approximately 70 per cent of the birds left in pairs; the remainder left singly. Those that left singly were apparently birds leaving mates that were incubating eggs. The relative number leaving singly therefore proved to be an indication of the current progress of nesting. About one-third of the burrows examined in March contained birds incubating eggs.

Departure ceremony was noted only in pairs of birds preparing to leave the island and may be interpreted as a mutual display. Displays began by one of the pair uttering

a loud *kree-er*, similar to the alarm cry. The mate responded by coming to the former's side, and they both advanced together toward a takeoff point. One of the pair always took the lead with the other following immediately. Often the pair would sit at the takeoff point for five minutes or more, then without apparent reason the birds would rise off their tarsi, back step, bounce two or three times, bow and fly off uttering *chirr-chirr* or *squeer-squeer* cries. The ceremony was always the same and was readily recognized by the back step, bounce and bow. Single birds merely *squeered* as they departed.

OTHER ACTIVITIES

As in murre, guillemots, and other alcids, Cassin Auklets often skitter over the surface of the water paddling with the feet and flapping the wings on the water surface. This motion has been described previously in detail for the alcids and it has been suggested that the habit is due to a conflicting drive to dive and to fly (Storer, 1952:135-136). Skittering is usually demonstrated during disturbance and confusion out at sea and was observed at sea as the ship approached a scattered flock of auklets. It was also observed during water activity experiments conducted in a confined surge channel.

Auklets resting or sleeping on the water surface dive so rapidly that the human eye barely sees the motion. They disappear in a fraction of a second. Even in motion studies made on 16mm. film at 64 frames per second the actions appear very rapid. Periods between dives during feeding sessions are rarely longer than 30 seconds in duration. The longer pauses are taken up by stretching, ruffling the feathers, head-shaking and bill-dipping. The duration of submersions ranged from 45 to 60 seconds.

Bill-dipping is a habit of the alcids which has been the subject of considerable speculation. The following suggestions have been offered: false drinking, looking for underwater predators, a mechanism for keeping food moist, locating prey before diving, and the rinsing off of secretions from the salt gland. In a former paper on the Pigeon Guillemot (Thoresen and Booth, 1958:28) we suggested that bill-dipping served to keep fish fresh and moist that are to be delivered to the young. This hypothesis seemed to fit the picture for the Pigeon Guillemots and puffins since fish are sometimes held for hours before being carried to the nest. In the auklet, however, food is carried internally and there would be no such requirement for keeping fish moist. Storer's suggestion (1952:135) that the habit may have an important function in locating prey before diving may contain some truth. But this concept does not, as he also points out, account for the fact that the mannerism increases in frequency when the birds are disturbed. It should be noted that diving impulses may be associated with the catching of prey and the escape from enemies, hence the reason for the increased bill-dipping activity during disturbances.

ECTOPARASITES

Three types of ectoparasites were collected from the auklets, but no adverse conditions were noted associated with their presence. An unidentified species of shaft louse was common on the wing feathers, and chicken mites (*Dermanyssus*) were frequent around the head and wing regions of auklet chicks and juveniles. A few fleas identified as *Actenopsylla suavis* were found occasionally among the belly down on the auklets.

SUMMARY

Studies of the breeding behavior and growth rates of the Cassin Auklet (*Ptychoramphus aleutica*) were conducted intermittently in the period from June, 1958, to March, 1960. Visits were made to bird colonies during the summer months and at various other intervals. Most of the observations were conducted on the Farallon Islands,

California, between May, 1959, and March, 1960. A new nesting colony was located on Castle Rock, near Crescent City, California.

Seventy-five nests were included in the study of the incubation, growth, fledging periods and nesting success of the young. The incubation period was shown to be at least 37 days.

Approximately 175 hours were spent in observations of the nocturnal behavior of auklets.

Various behavioral displays are described as associated with mating, burrow excavating, fighting, preservation of the pair bond, and recreation. Among the more active displays were weed plucking, billing, passing, wing-raising, calling, forward-jabbing, face-to-face combat, leap-frogging, tagging and departure ceremonies. The activities of the birds while at sea are briefly discussed and it is suggested that the habit of bill-dipping is associated with the diving impulse which is linked with the catching of food and the escape from enemies.

Total mortality of eggs and young was 73.4 per cent, but 65.5 per cent of the chicks which hatched successfully reached maturity. The average fledging period was found to be 44.7 days.

Adults usually stay in the burrow with their chick for three or four days until the young can maintain its own body temperature. The young develop slowly until about the fifteenth day when growth becomes more rapid. The average daily gain in weight proved to be 4.18 grams until the thirtieth day when the weight began to fluctuate. Nineteen live adults averaged 172.64 grams in weight.

Gulls are the chief predators on the auklets, but the adult birds, although killed by the gulls, were not always eaten. The gulls seemed to prefer the young auklets as food.

Among the most interesting habits described is the departure ceremony which is displayed by mated pairs early in the season before leaving the nest area for the day at sea. This behavior is characterized by a backstep, bounce and bow. Bill snapping by the adult and location calls by the young guide parent birds to their young in total darkness.

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