BREEDING BIOLOGY OF THE HAWAIIAN DARK-RUMPED PETREL IN THE HAWAIIAN ISLANDS

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The purpose of this paper is to present some of the initial findings of a three-year study begun in 1979 on the breeding biology and ecology of the Hawaiian Dark-rumped Petrel (Ptero-droma phaeopygia sandwichensis) and to provide an overview of work in progress.

The Hawaiian Dark-rumped Petrel or 'Ua'u is one of two endangered subspecies; the other, Pterodroma phaeopygia phae-opygia, nests in the Galapagos Islands (Harris 1970, 1973). Like most Procellariiformes, Hawaiian Dark-rumped Petrels are truly pelagic birds that spend much of their life over the open ocean, visiting land only to breed. They are nocturnal, burrow-nesting birds showing many of the attributes of an intensely K selected species. They are long-lived with delayed maturity and a low reproductive potential; each pair produces only a single egg per year which is not replaced if it is lost. For these reasons the recovery rate of a disturbed population can be expected to be slow and there is a very real potential that an apparently stable population could decline rapidly with little warning.

There is ample historical evidence that Hawaiian Dark-rumped Petrels have been severely disturbed in Hawai'i and have been eliminated from most of their former nesting areas. Perkins (1903) noted that the species was "common in many parts of the islands, nesting in the high mountains, where it forms large nesting colonies" and it appears that it was once abundant on all of the main islands except perhaps O'ahu. Archaeological evi-dence indicates that huge colonies must have existed in the past on the island of Hawai'i. Munro (1955) commented on the pop-ulations on Moloka'i stating, "I was told that on its arrival at Pelekunu Valley, Moloka'i, in the evening it darkened the sky." Today, as a result of predation by introduced mongooses (Herpestes auropunctatus), rats (Rattus spp.), and feral cats (Felis catus) as well as hunting of the birds by native Hawaiians, prized the chicks as a delicacy, the colonies of Hawaiian Dark-rumped Petrels have been reduced to several small, remnant populations.

The purpose of our study is to collect basic information on the natural history, breeding biology, and population dynamics of the remaining populations of Hawaiian Dark-rumped Petrels and to identify the factors that are currently threatening their survival. Our primary goal is to examine the effect of predation and other factors limiting reproductive success in the hope of developing a simulation model for the remaining populations. This information will give us an indication of the recovery potential of the species in the future and contribute to the development of a management plan.

Hawaiian Dark-rumped Petrels are presently found on the islands of Hawai'i (Richardson & Woodside 1954; Banko 1980); Lāna'i (Shallenberger 1974); Maui (Richardson & Woodside 1954); and perhaps Moloka'i (C. Kepler, pers. comm.). On Hawai'i birds have been heard at upper elevations along the southwest rift of Mauna Loa and several active burrows have been located near Pu'u Kole on the southeast slope of Mauna Kea. On Lāna'i, a potentially sizable population may exist along the ridges of Kumoa Gulch at an elevation of 825 m. Although birds have been heard calling in this area for many years from May to August, a nesting colony has not been located.

The largest and most important nesting area known thus far is located within Haleakala National Park (HALE) on Maui. Over the past 15 years Park personnel have located more than 500 burrows, most of which are found along the heavily eroded west rim of the crater between the elevations of 1800 and 3000 m. Small groups of burrows have also been located along the south rim, on the face of Hanakauhi and outside of the Park below the "Science City" complex and along the outer west slope of Haleakalā.

Burrows are commonly located at the base of rock outcrops where the accumulated erosional debris provides a high degree of local relief. Nest sites are highly variable; natural crevices less than 1 m in length are utilized as well as cracks and lava tubes that penetrate over 15 m into the cliff face. Petrels will also excavate extensive tunnels into softer substrate usually beneath a large boulder or rock ledge. We are looking into the potential of creating nesting habitat and increasing the accessibility of nesting birds for research purposes by providing artificial burrows in several locations. However, none of the nest boxes have been occupied thus far.

Birds were active at the colony in early March of 1979 suggesting that they arrived in late February and perhaps earlier. Active burrows can be identified by droppings at their entrances and occasionally by the presence of recently collected nest material and freshly excavated dirt.

The pre-laying period which extended for over two months, seems to be an important time for birds to form or maintain pairs and to prepare the burrows for nesting. The birds returned frequently to their nests in March but activity dropped off sharply during a pre-laying absence in April. Egg-laying appears to be synchronous, beginning in early May and extending for a period of about two weeks. It seems that as in most Procellariiformes the male visits the burrow frequently prior to egg-laying while the female is at sea obtaining food reserves to produce the single, large egg. The average weight of nine newly laid eggs was 74.11 g (S.D.±7.64) which represents over 21% of mean adult weight. In a single case observed directly during the 1980 season, the female returned briefly to lay the egg and the male, who had been visiting the burrow regularly prior to that time, took the first incubation shift.

Information on the attendance patterns of the birds is being collected from 10 event-recorder monitored burrows. The recorder, activated by a two-way switch placed over the burrow entrance, has been incorporated into an interpretive display about the Petrels in the House of the Sun Visitor Center, Haleakalā, Maui. Adult birds exchange incubation duties at night and the recorder information indicates that individual shifts can extend for up to 18 days. Although some birds begin to arrive at the colony as early as one-half hour after sunset and departing birds leave prior to sunrise, individual birds arrive at and depart from their nesting burrows at irregular hours throughout the night. Information provided by the recorder is being supplemented by the direct observation of an active nest from a nearby blind.

Nesting failures during incubation were common in 1979 and resulted from a combination of natural and unnatural causes. Of a sample of 44 nests in which eggs were laid, seven eggs were infertile or ejected for unknown reasons; eight eggs were eaten by predators, presumably mongooses; and six nests failed when incubating adults were killed on the nest by feral cats or mongooses.

The first chick hatched on 1 July 1979 and hatching continued until the middle of the month. Newly hatched chicks weigh approximately 60 g and they are brooded continuously for several days following hatching. After the brooding period adults leave the chicks alone and are found in the burrows only when they return periodically at night to feed them. The development of the chicks is slow presumably reflecting an adaptation to the variable and unpredictable food supply utilized by the adults. During some periods chicks were visited for six continuous nights while at other times they were without food for over 12 days (Fig. 1). This pattern is reflected in the large variance of the combined chick weight data (Fig. 2). In general, chicks gain weight steadily until day 55 when they reach an asymptote of about 550 g, with some chicks attaining maximum weights of almost 800 g or twice adult weight. Chicks begin to lose weight on about day 80 and continue to do so until they fledge. In contrast to weight, the growth of body parts is much more uniform and it is interesting to note that day 55 represents an important turning point in the growth of the chick. Wing growth shows a typical logistic pattern with the inflection point at approximately 55 days and maximum length of approximately 300 mm reached just prior to fledging at about 110 days (Fig. 3). Tarsus growth is linear initially, but reaches an asymptote of approximately 42 mm near day 55 (Fig. 4). Culmen growth shows a similar pattern reaching an asymptote of approximately 30 mm also on about day 55 (Fig. 5). In contrast, primary growth is not initiated until day 50 and proceeds linearly until fledging (Fig. 6). The pattern suggests that the change that occurs at about day 55 is the result of a transition from the growth of tissue and body parts to the growth of feathers.

Fledging began on 12 October 1979 and continued into early November. Some chicks were visited consistently prior to fledging while others were deserted for periods of up to three weeks. The mean nestling period for 12 chicks monitored in 1979 was 113 days (S.D.±3.1 days) ranging from 110 to 117 days. The extended nesting period of almost four months provides ample opportunity for chicks to fall victim to predators. Of a sample of 21 nestlings only two chicks died of natural causes, apparently starvation, while seven were killed by cats and mongooses. Thus, based on 53 active nests whose fates were positively determined we can summarize reproductive success as follows: 44 eggs were laid, producing 21 chicks and 12 fledglings for an overall reproductive success of approximately 27%. Extrapolating these figures to an estimated 300 active burrows in Haleakalā in 1979, approximately 80 chicks would have fledged that year. Over 80% of the nesting failures can be attributed directly to predation. It is important to keep in mind that even under optimum conditions we would expect that the period of highest mortality would be between fledging and the attainment of breeding age.

We have established a trapping grid covering the entire west rim colony to examine the predation problem. It appears that a small number of predators were responsible for most of the nesting failures last season. One feral cat and three mongooses were trapped on the colony for the first time last summer; however, despite an intensive trapping effort sporadic instances of predation occurred periodically. Most of the predation occurred in burrows near the road suggesting that animals were entering the colony from the west slope of Haleakala. It is clear that if the predator population increases by even a small amount in the future, the effect on the remaining Petrel populations could be devastating. In 1979 we trapped exclusively with Havahart live traps but since we were only partially successful in controlling the predation problem we are now experimenting with homemade wooden tunnel type traps. Local Maui trappers claim that these traps are considerably more effective for trapping mongooses and cats than any of the commercially available traps. We are also experimenting with captive mongooses and cats to gain an understanding of their general behavior, food preferences, and attraction to various types of baits and chemical attractant scents.

In summary, the findings of the study to date that are most important for the conservation of the Hawaiian Dark-rumped Petrel in Hawai'i are as follows:

1. Haleakala National Park currently contains the only known breeding population of the Hawaiian Dark-rumped Petrel.

2. The population is small and reproductive success was low in 1979.

3. A potentially serious predation problem exists which could be disastrous to the remaining birds if it is not controlled in the near future.

On a more positive note, reproductive success last season would have been extremely high had it not been for the unnatural predation. If we can control predation in the future, there is every reason to believe that the Dark-rumped Petrel population within Haleakala National Park could begin to recover.

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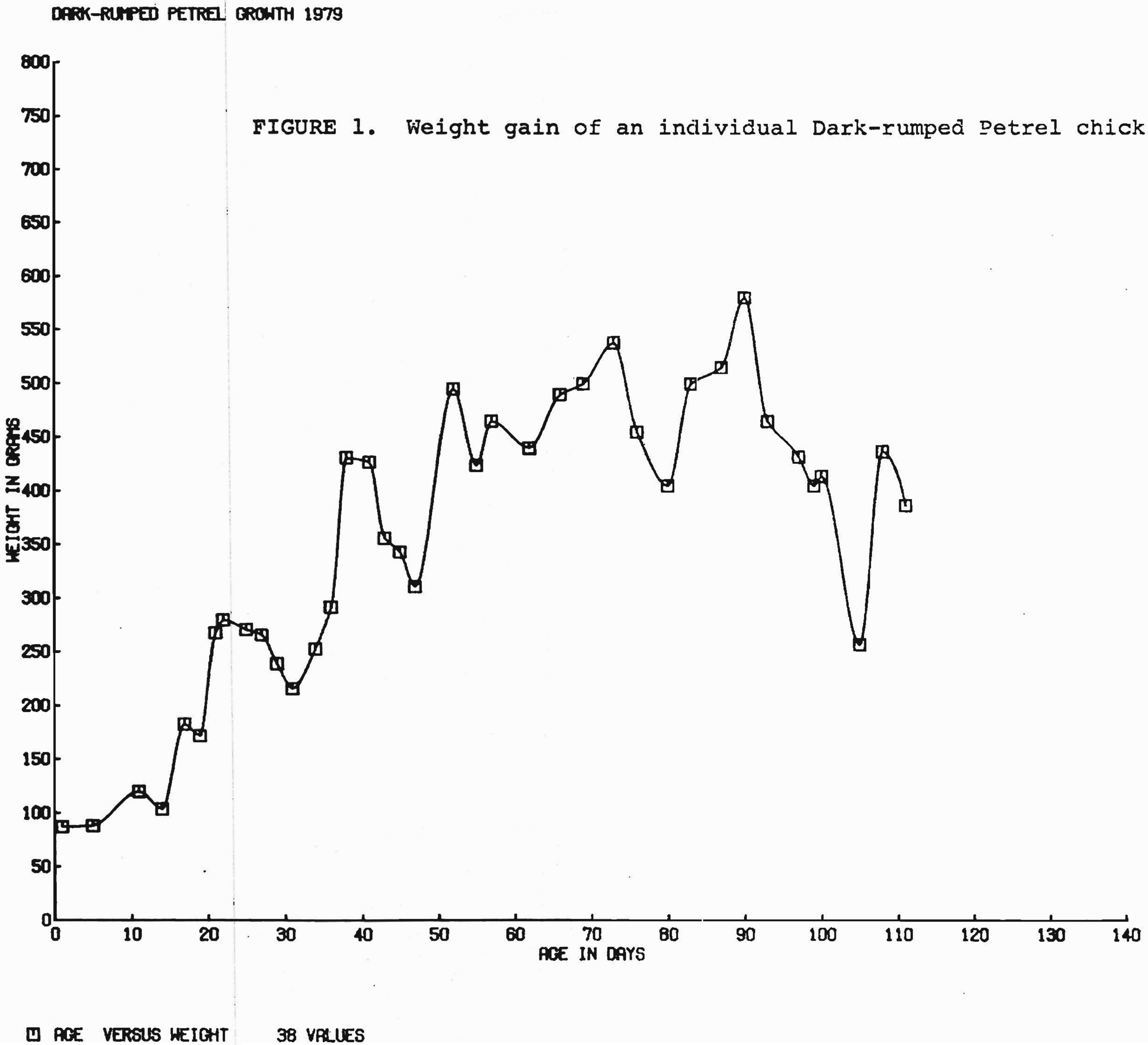

FIGURE 1. Weight gain of an individual Dark-rumped Petrel chick.

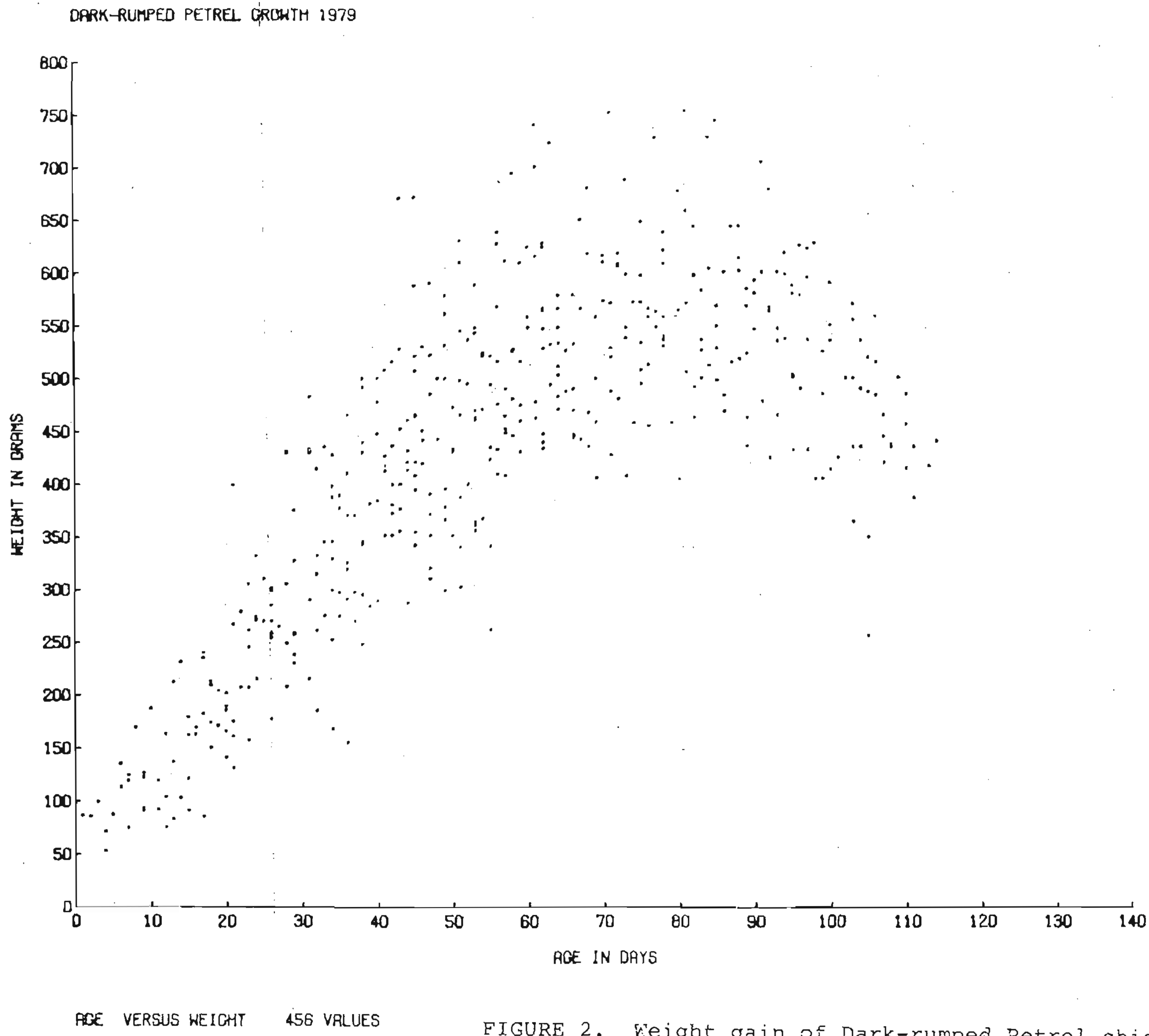

FIGURE 2. Weight gain of Dark-rumped Petrel chicks.

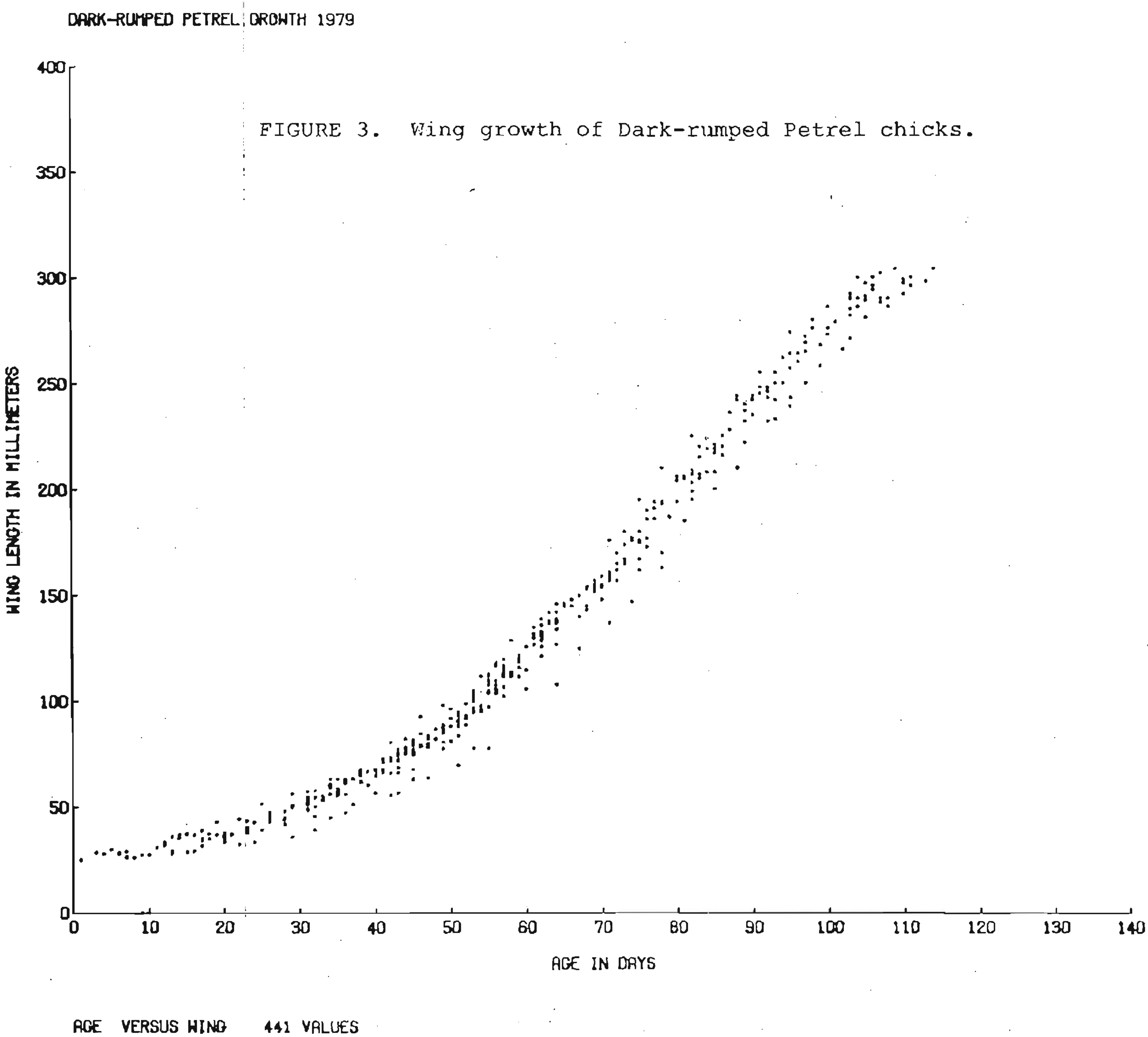

FIGURE 3. Wing growth of Dark-rumped Petrel chicks.

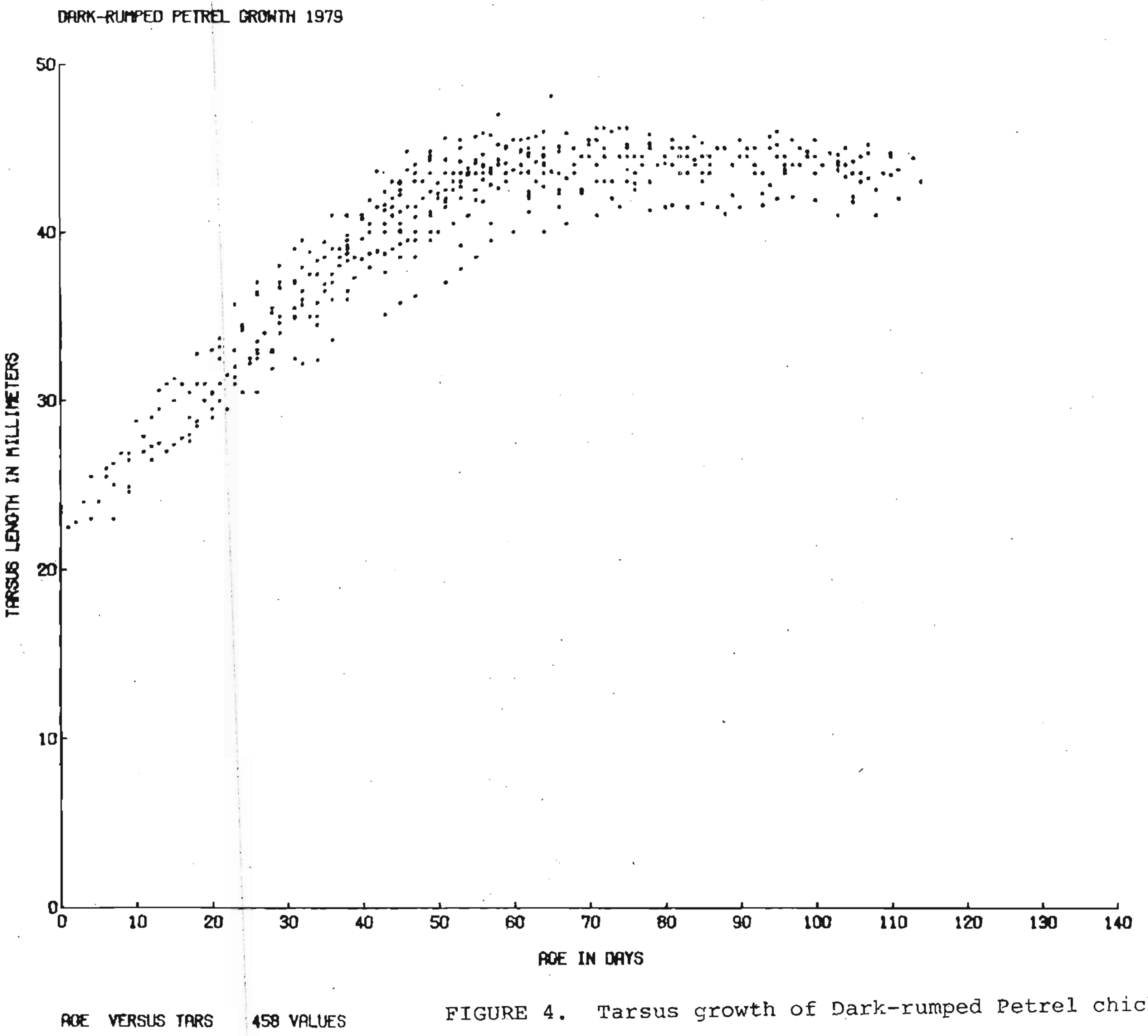

FIGURE 4. Tarsus growth of Dark-rumped Petrel chicks.

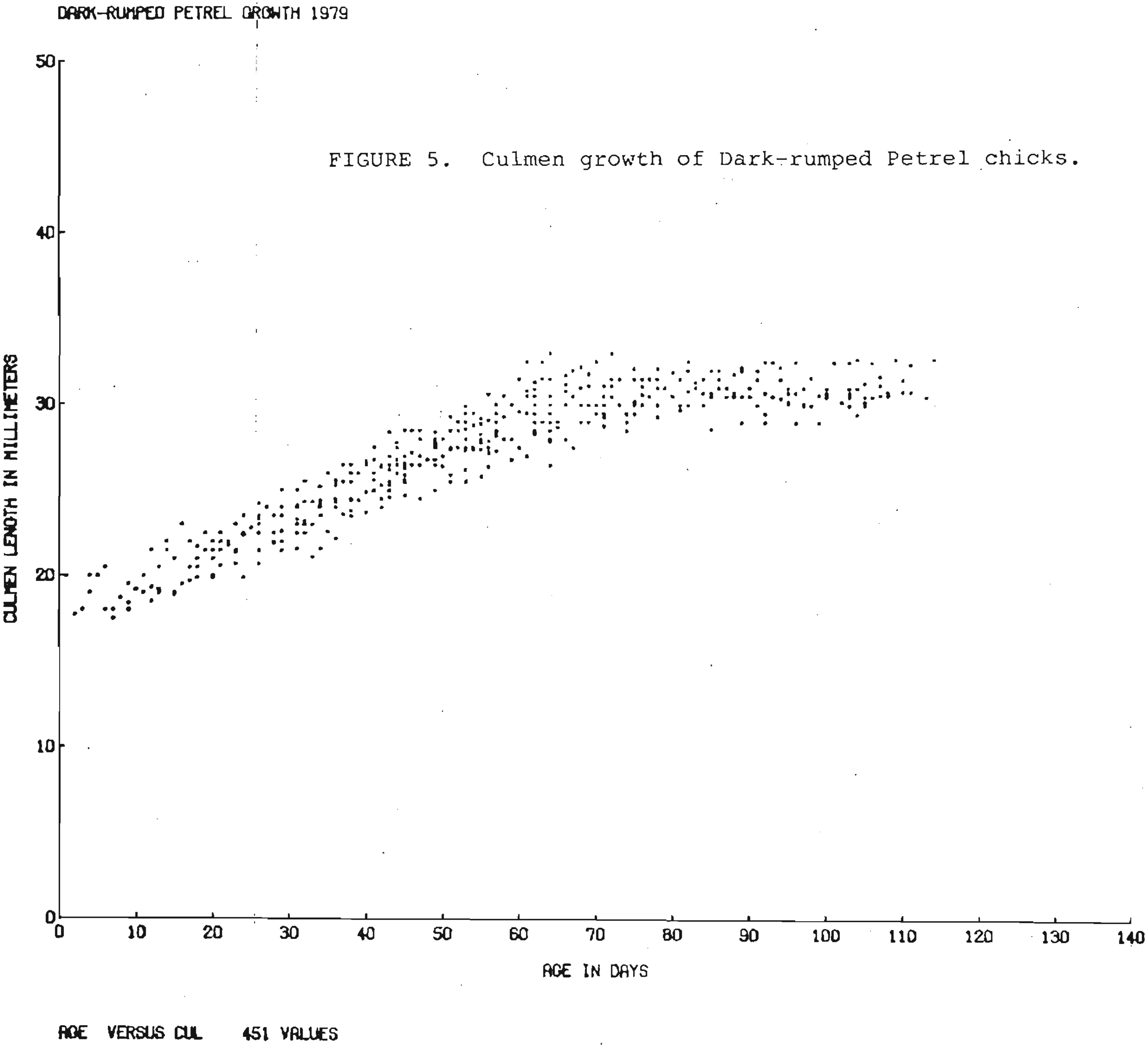

FIGURE 5. Culmen growth of Dark-rumped Petrel chicks.

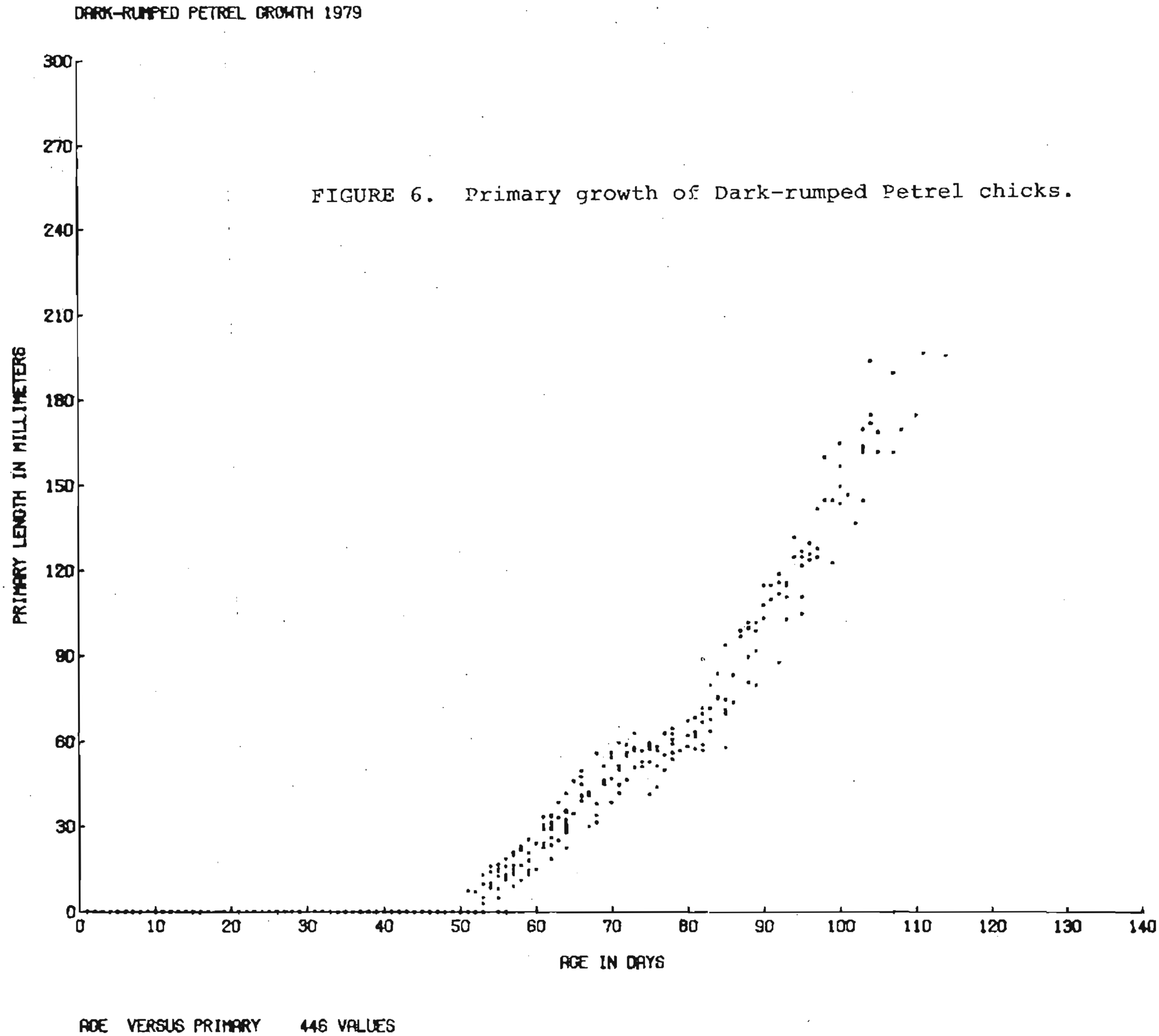

FIGURE 6. Primary growth of Dark-rumped Petrel chicks.