ESTIMATING EFFECTS OF DIOXINS ON WILDLIFE POPULATION —A CASE STUDY WITH COMMON CORMORANT—

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Introduction

It has been reported that wildlife in Japan have been contaminated by dioxins (PCDDs, PCDFs, and co-PCBs) and that the levels in fish-eating birds are especially high [1,2,3,4,5,6]. In present study, we attempted to quantify the effect of dioxins on common cormorants, in reference to the population-level effects. Particularly we estimated the effects of dioxin exposure in Tokyo Bay sediment onto the common cormorant (*Phalacrocorax carbo*) population in two ways. Firstly, the changes in intrinsic growth rate, and secondly, the changes in gross population size. The effects of dioxins were estimated utilizing population dynamics theory and the available field data. The intrinsic growth rate, which integrates fertility and survival rate, is considered to be a suitable measure of responses to toxicants because it is a biologically relevant parameter [7,8].

Target Population

Common cormorant population at Shinobazu Pond in Tokyo, Japan was selected as the target subject. Because, fish-eating birds such as common cormorants are suitable biomarkers of lipophilic, persistent organochlorine compounds [9,10]. Moreover the theory of population ecology was applicable to this population. During the period from 1971 to the mid-80s, it was reported that Shinobazu Pond had the only one colony of common cormorant in the Kanto region [11,12,13]. Those observations suggested that the population could be treated as isolated without immigration and emigration during foresaid period. And this population had been the subject of detailed investigation regarding population size and reproductive outcome after 1973 [11,14,15,16]. Thus, the demographic data necessary for estimation of population-level effects were also available.

Procedure for Estimating Population-Level Effects

It is reasonable to assume that the population observed between 1971 and the mid-80s was exposed to dioxins at considerable levels. However, it is unknown how the population would grow under dioxin-free conditions. Thus, we estimated the intrinsic growth rate without exposure to dioxins (*r*), following the concept shown in Fig.1.

First, we estimated the intrinsic growth rate with exposure to dioxins from the observed population size in 1974-1986. Next, we calculated the intrinsic growth rate without exposure to dioxins. In a mean time, the residual level in egg upon exposure to dioxins used in this study was based on the estimates from Iseki *et al.*[5] For purpose of this example, it is assumed that egg mortality rate due to exposure to dioxins was constant. By this means, we calculated the intrinsic growth rate under dioxin-free conditions. The procedure of the calculation is shown in Fig.2.

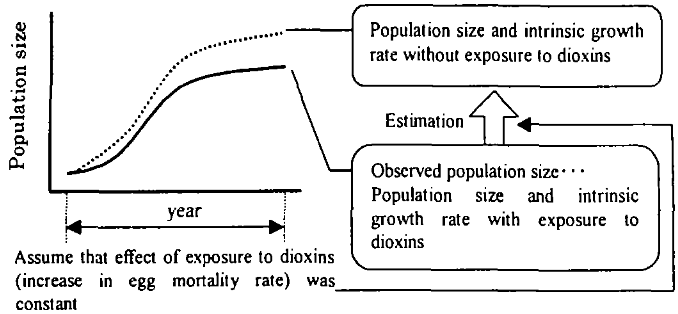

Figure 1. Concept of Estimating Population-level Effects

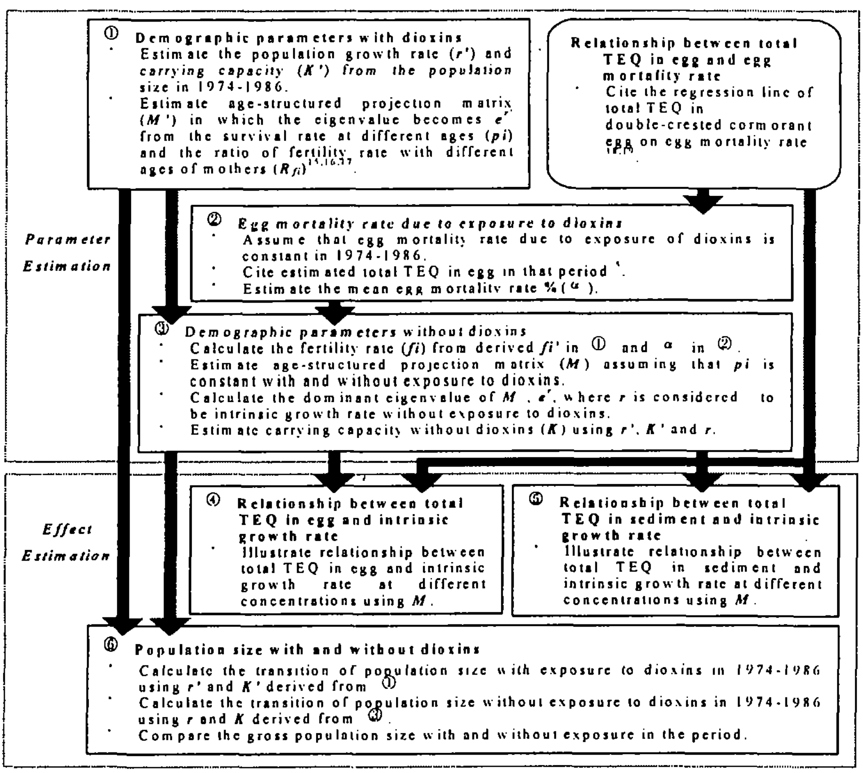

Figure 2. Procedure for Estimating Population-level Effects

Results and Discussion

Fig.3 illustrates the changes in intrinsic growth rate (y-axis) with the increase in egg mortality rate posed by the increase in total TEQ in egg (upper x-axis) caused by exposure to dioxins from sediment (under x-axis). The figure also indicates the level of intrinsic growth rate would change by continued exposure to dioxins at certain level on horizontal axis. The results explain that the intrinsic growth rate at the total TEQ in egg during 1974-1986 was decreased to 89% with comparison to that under dioxin-free conditions, which in considered as 100% (r = 0.405 $\rightarrow$ r' = 0.360). This is sufficiently high intrinsic growth rate to allow recovery from a small population size. In addition, we estimated the change in gross population size for the cases with and without exposure to dioxins. The gross population size with exposure to dioxins in that period was declined to 85% with comparison to that without exposure to dioxins.

Besides, the current average total TEQ in eggs collected around Tokyo Bay in 1998 was reported as 220 [WHO-TEQ(bird) pg/g wet wt. basis][4]. Based on our estimation, it is predicted that the current cormorant populations around Tokyo Bay are not confronted with the situation of decreasing in population size by a factor of increase in egg mortality rate caused by exposure to dioxins.

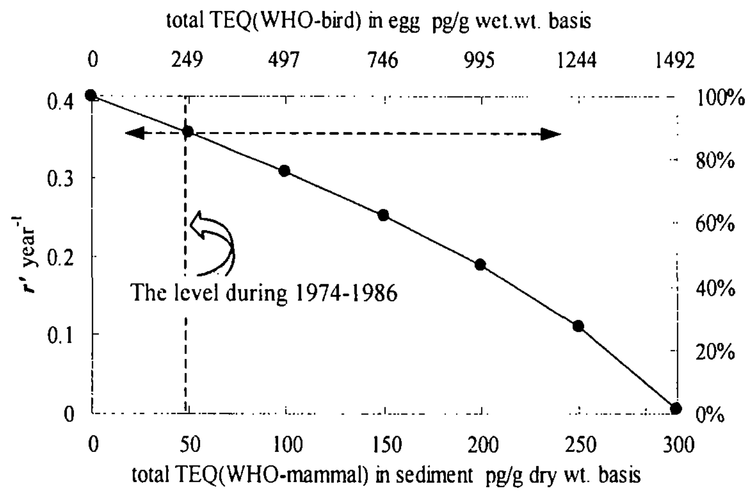

Figure 3 Relationship between total TEQ in sediment or egg and intrinsic growth rate

The regression line of total TEQ in double-crested cormorant egg on egg mortality rate by Ludwig *et al.* was used in the calculation[19]. Total TEQ in egg (upper x-axis) was calculated using the composition ratio of congeners in sediment during 1977-1981obtained from sediment core sampled from Tokyo Bay by Yao *et al.*, and using the method of Iseki *et al* [20,5]. The estimated value of total TEQ in egg during 1974-1986 is 240 WHO-TEQ (bird) pg/g wet wt. basis.

The left y-intercept is interpreted as the intrinsic growth rate under the dioxin-free condition (r).

As far as our concern, this study is the first to assess the effect of exposure to dioxins on wildlife population in Japan. The site-specific, population-level effect of dioxins could be estimated quantitatively based on the simplified assumptions.

Acknowledgments

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