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How Many Pheasants (*Phasianus colchicus* L.) can be Removed? A Study on Small- Protected Areas in Italy

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Abstract: In Italy the maintenance and the increase of wild pheasant populations is mainly obtained in small-Protected Areas (PA) suitable for wildlife reproduction. In these areas a part of the resident population is regularly captured and transferred to the hunting zones in the winter time. The aim of the study is to determine the right number of pheasant to be removed from this protected area without causing damage and thus maintaining a balance in the resident population. Since 2000, flush counts census were conducted in 30 PAs in the Florence province during the summer time (post-reproduction period), using dogs experienced at rooting out the pheasants. We made estimates for each PA in the number of adult males, adult females and sexually undifferentiated young pheasants. We calculated post-reproduction density and the ratios of young/adults and males/females. These parameters were used to construct a model to predict the pheasants catches in the next winter.

The study showed that the minimum census surface covered must be more than 9% of the total area studied. Smaller coverage gave biased estimations of pheasant numbers to be caught. The best generic model, to be used for surfaces between 297 and 1385 ha, located in Mediterranean habitats, was the following: total number of pheasants to be captured and relocated = -10.3 + 0.15*total number of female pheasants estimated in the protected area + 0.14* total number of young pheasants estimated in the protected area + 0.04*total surface of the protected area (R^2 = 0.48).

Keywords: Capture, flush counts, demographic parameters, harvest plan, pheasant, stepwise.

INTRODUCTION

The pheasant (*Phasianus colchicus* L.) is at present, with the wild boar and the hare, the most important hunting species in Italy. The request by hunters for increased quantities of pheasants has lead to the development of game breeding farms, which have provided ever-growing quantities of pheasants at lower prices. The improvement of the technical knowledge on pheasant breeding, directly derived from industrial poultry breeding, has broken the link between the game farmer and the area where the animals should have been released. This fact has led to the introduction in the farms of pheasants from all over the world (North Europe, America and even China) mainly with the aim to reduce the growing problems of inbreeding [1]. The best pheasants under the farm point of view, obtained by the cross of pheasants coming from all over the world, have been consequently diffused in every breeding farm and, then, in the wild. The survival rates of the captivity reared pheasants, however, are scarce and their contribution to the reproduction of the wild resident populations is very low. In fact the genetics of the captivity reared pheasants is quite similar in the different farms but the wild pheasants, living in the protected areas where the captive reared pheasants are not released, differ from a genetic point of view in the different protected areas and parks [2,3]. For these reasons many hunters do not yet appreciate the captive reared game and want to hunt wild born game. Therefore, political and technical managers of the hunting activity have been forced to put, alongside the easy repopulation practice with breeding game, more progressive strategies designed to increase the wild pheasant availability [4,5]. This took to innumerable pheasant repopulation projects both for direct hunting aim and for the natural population reconstitution.

Italian legislation (L. 157/92, article 10) and later also regional ones (L.R. Tuscany 3/94, articles 16) have identified in the “Repopulation and Capturing Zones” (Z.R.C), small Protected and managed Areas, where hunting and release of captive reared pheasant is forbidden, (below P.A.), the sites deputized to the maintenance and the increase of the wild populations of pheasants and hares. Therefore the development and the correct management of the PAs have become the fundamental elements for wildlife management improvement. Besides the natural dispersion of the pheasants out of the perimeters of the PAs, captures of wild subjects inside these zones in the winter time are also to be made in order to move the animals to the areas assigned to the hunting activity [5]. The captures and the relocation of the pheasants are necessary because the protected areas are by law only the 20-30% of the territory and the natural dispersion from these is not sufficient to encompass the entire free-hunting areas. The correct dimensioning of the number and the typology of the pheasants to be captured (harvest plan) and the number and the type of the parameters to be used for the definition of the captured pheasants, are therefore fundamental for a more productive management and as a result simultaneously steadying for the resident

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population [6]. The aim of the study is to determine the right number of pheasant to be removed from this protected area without causing damage to the natural balance of the resident population. For this reason we have considered useful to submit critical investigation of the parameters which are commonly registered during the census for monitoring wild pheasant populations [7-9] in order to determine the best predictive model, limiting demographic variables, to apply to the harvest plan estimation. This study is therefore not only important in deciding the number of pheasants to remove from the PAs, but also in a general level, such as any occasion in which there is a need to determine a pheasant harvest plan from wild populations (e.g. in private hunting or non hunting areas surrounded by public hunting territories).

MATERIALS AND METHODOLOGY

In 1999 the management of the Province of Florence PAs changed from the Provincial Administration to the Local organisation for Wildlife and hunting Management of Florence (below LWM-Fl), in Italy named ATC-FI5. Since 2000 the LWM-Fl, has been monitoring the pheasant populations inside its 30 protected areas (from 297 and 1385 hectares) through the method of complete flush counts with dog-help in standardised areas during the post-reproduction (summer) period, according to the method of Hill and Robertson (1988) modified by the Italian National Institute for Wildlife [6]. We used this census method because with it we obtained a density, a sex ratio and a measure of the reproductive success. With this method 3-4 census surface samples inside each of the 30 protected areas of LWM-Fl are first localized on the map and then on the territory. If we think of this surface sample like a rectangle, on three sides of the perimeter we put some people (the observers: 7-13) at the max distance of 30-40 meters one after the other; the observers only count the animals who leave the census area. From the remaining fourth side of the hypothetical rectangle, some hunters with specialised dogs (8-16) move from the perimeter to the centre of the census area and drive all the pheasants present in the area towards the observers. The hunters with dogs only count the animal passing over their shoulders. The census was coordinated by the wildlife managers of LWM-Fl, assisted by a variable number of volunteers (from a minimum of 10 to a maximum of 30 participants). The total sampled surface for each protected areas varied from 27 to 152 hectares. Every year the census was carried out during the same period and with the same weather conditions. The complete census of the bird population, which can be obtained in this season by dog help, and the number of observers guarantee from biased estimates of population presence [6].

During the census we counted adult males and females, and juveniles, of undefined sex, in the census surface and from these we estimated the pheasant number for every class (sex and age) for the total surface of each PA, comparing the number of animals counted over the census area with the total surface area (data obtained for each PA: estimated adult males, estimated adult females, estimated young pheasants, total number of estimated pheasants). After that we estimated the following demographic parameters, for the total surface of each protected area: Post-reproduction density, young/adults and males/females ratios.

During the 6 years of management, the number of pheasants captured in the following winter time was decided by wildlife managers of LWM-Fl on the basis of their experience. The number of the pheasant to be captured changed (increased or easily decreased) during the capturing sessions, depending on indication of the volunteers, instructed to do these operations, and of their observations regarding the number of animals present in the period of captures in the protected areas. The density and capture data, noted during 6 years of management, are summarised in Table **1**.

Statistical Analysis

Pheasants densities, estimated inside the PAs, analyzed using a log-link function, were submitted to two-segmented regression model, in relationship to the percentage of the sampled surface to find the change point (The total non linear regression was divided in two linear regressions and the change point was identified when the two linear regressions reached the total least squares value) [10-12]. Non-biased data (surfaces censused greater than 9%), coming

Table 1. Average Density and Demographic Ratios (with Standard Deviations) Derived from Annual Censuses in 30 Protected Areas Managed by the LWM-Fl. Also Shown are the Corresponding Demographic Ratios of Birds Captured After the Breeding Season for Recruiting to Hunting Areas

Year	Surface		Output of Census Data						Output of Capturing Data			
			Density		Young/Adults		Males/Females		Captured Pheasants		Males/Females	
	ha		n./100 ha		Ratio		Ratio		n./100 ha		Ratio	
	Avg.	Std. d.	Avg.	Std. d.	Avg.	Std. d.	Avg.	Std. d.	Avg.	Std. d.	Avg.	Std. d.
2001	604	244.8	207	177.0	0.78	0.386	1.01	0.357	21	16.1	0.6	0.20
2002	603	247.4	184	133.4	0.99	0.858	1.10	0.488	18	10.0	0.5	0.15
2003	604	247.4	183	95.3	0.89	0.497	1.10	0.426	15	7.2	0.4	0.20
2004	599	237.8	166	108.8	0.96	0.588	1.02	0.400	15	10.0	0.7	0.22
2005	599	237.8	155	104.3	1.01	0.534	1.02	0.413	16	11.2	0.7	0.22
2006	599	237.8	165	93.3	1.41	0.958	1.14	0.515	17	9.8	0.8	0.39

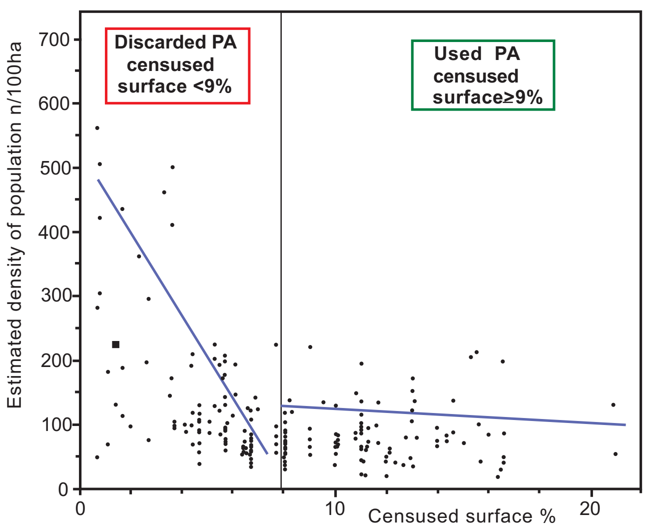

Fig. (1). Bivariate fit of estimated pheasants population by percentage of censused surface.

from the post reproduction censuses (absolute data, and densities), were then tested with a preliminary analysis of all the possible linear regressions in relationship to the real catches. The multivariate complete model of all the data coming from the post reproduction censuses was then submitted to the stepwise selection of the most significant variables. The significance probability that was attributed to a regressor term for it to be considered as a forward step and entered into the model was 0.25. The significance probability that was attributed to a regressor term in order for it to be considered as a backward step and removed from the model was 0.10. Since absolute values best fitted in all the linear regressions, we used only the absolute values in the multivariate model and, consequently, the surface was lock between the entered parameters [13].

RESULTS

Parameters shown in Table **1** show that the density seems to decrease slightly from 2001 to 2004 (no statistically significant) but remains constant in the three following years. The young/adults ratio increase in favour of young and the males/females ratio turns out in general unchanged.

The two segmented regressions with the change point shown in Fig. (**1**) highlights how the censuses made in a sampling area below 9% of the total surface of PA (1.17 std.err.) show a significant negative linear relationship between the sampled surface percentage and the esteemed population density while, when the sampled area is greater than 9%, the estimated densities seem independent from the percentage of the censused PAs.

The simple linear regressions of the various demographic parameters are shown in Table **2**; every record deriving from sample areas lower than 9% of the PA surface has been discarded. The results confirmed that, in the case of the use of a single demographic parameter to predict the number of pheasants to be captured, the best parameter to be chosen is the total number of estimated pheasants in the PA (R^2 = 0.76 for the densities and R^2 = 0.81 for the absolute values, covaried by the measured PA-surface), closely followed by the estimated young (R^2 = 0.76 for the densities and R^2 = 0.81 for the absolute values, covaried by the measured PA-surface). The densities, commonly used by the wildlife managers, always gave a lower value of the proportion of the variation in the response that could be attributed to the term in the model rather than to random error than the absolute values covaried by the surface.

The best possible combination of the various demographic parameters, identified by stepwise selection, is shown in Table **3** and Fig. (**2**). Results have shown how the surface of the protected area with the absolute number of females and young, both estimated in the summer post-reproduction time, are the best parameters to predict the number of pheasants which will be captured in the next winter. The two other parameters selected by the model are single PA and year.

The generalised estimate of the number of pheasants to be captured, coming from the analysis of the winter captures and the summer census obtained by the data observed in the 27 protected areas of the province of Florence for 6 years, was: (see the formula at the end of the page).

DISCUSSION

Demographic and Density Parameters

The data of population dynamics inside the PAs, highlight interesting results, especially if compared to data obtained in similar [14] or northern habitats [15-17]. The young/adult ratio is extremely low in the post-reproductive period during the six monitored years, particularly if compared to the reproductive species capacity (maximum observed value: 1.41 young for every adult in the census in the August-September period). The young/adults ratio, however increased during the years in favour of young and the males/females ratio turns out in general unchanged. The reasons for these parameters of density and demography can be explained by the characteristics of the areas used for the management of the hunting. Inside the PA the hunting is forbidden, but the PA is surrounded by area where hunting is allowed. The summer census are carried out when the season of hunt is closed everywhere. For this reason animals, especially young's, move naturally outside of the PAs. After

$$\text{total number of pheasant to be captured} = -10.3 + 0.15 * \text{total number of female pheasant estimated in the PA} + 0.14 * \text{total number of young pheasant estimated in the PA} + 0.04 * \text{total surface of the PA}$$

Table 2. Parameters which Affect the Number of the Captured-Pheasants in the Protected Areas (Since the Ratio Young/Females was Worst than the Young/Adults Ratio, we Reported Only this Last, and Better, Parameter)

Models:		**a**	**b**	**Year**		**PA**		**PA Surface**		**Model**		
Captured – densities (n/100ha)				**F**	**Prob.**	**F**	**Prob.**	**b**	**Prob.**	**F**	**R^2**	**Prob.**
a + b*estimated males/100ha + Year + PA	Est. value	13.2	0.08	2.87	0.017	6.08	<0.001			10.36	0.72	<0.001
	Std. Error	1.15	0.022									
a + b* estimated females/100ha + Year + PA	Est. value	13.7	0.07	3.28	0.008	6.86	<0.001			10.68	0.72	<0.001
	Std. Error	0.94	0.016									
a + b* estimated young pheasants/100ha+Year+ PA	Est. value	11.7	0.07	3.48	0.005	6.43	<0.001			12.16	0.75	<0.001
	Std. Error	1.04	0.012									
a + b* total estimated pheasants/100ha +Year+ PA	Est. value	9.4	0.04	2.87	0.017	5.37	<0.001			13.21	0.76	<0.001
	Std. Error	1.23	0.006									
a + b*males/females ratio + Year + PA	Est. value	20.5	-3.18	3.60	0.004	10.63	<0.001			9.55	0.70	<0.001
	Std. Error	1.58	1.403									
a + b* young/adults ratio + Year + PA	Est. value	15.0	2.06	4.18	0.001	10.69	<0.001			9.50	0.70	<0.001
	Std. Error	1.09	0.955									
Captured - absolute values n/PA												
a + b*estimated males + Year + PA + Surface	Est. value	-305	0.14	1.89	0.100	3.93	<0.001	b=0.61	<.0001	12.90	0.76	<0.001
	Std. Error	84.45	0.024									
a + b*estimated females + Year + PA + Surface	Est. value	-324	0.10	1.97	0.087	4.26	<0.001	b=0.65	<.0001	12.88	0.76	<0.001
	Std. Error	84.32	0.017									
a+b*estimated young pheasants+Year+ PA +Surface	Est. value	-311	0.07	2.91	0.016	5.20	<0.001	b=0.62	<.0001	14.91	0.79	<0.001
	Std. Error	79.73	0.010									
a+b*total estimated pheasants+Year+ PA +Surface	Est. value	-298	0.05	2.17	0.061	4.15	<0.001	b=0.66	<.0001	17.38	0.81	<0.001
	Std. Error	75.04	0.006									
a + b*males/females ratio + Year + PA + Surface	Est. value	-298	-15.8	2.17	0.061	7.93	<0.001	b=0.68	<.0001	10.04	0.72	<0.001
	Std. Error	95.5	8.68									
a + b* young/adults ratio + Year + PA + Surface	Est. value	-371	13.0	2.60	0.028	8.45	<0.001	b=0.75	<.0001	10.20	0.72	<0.001
	Std. Error	92.8	5.81									

Table 3. Stepwise Selection of the Parameters which Best Estimate the Pheasants which will be Captured (DFE =86; Rsquare = 0.66; MSE= 1142)

Parameters:	**Lock**	**Entered**	**n DF**	***SS***	**t Ratio**	***Prob>|t|***
Intercept		X	1		2.25	0.0271
Surface	X	X	1	93.10	-0.29	0.776
Estimated males			1	1396		
Estimated females		X	1	10477	3.03	0.0032
Estimated young pheasants		X	1	22338	4.42	<.0001
Males/females ratio			1	113.62		
Young/adults ratio			1	20.05		
Censused surface			1	4.066		
Year {two groups: 2005&2006&2004&2003-2001&2002}		X	1	7997	-2.65	0.0097
PAs grouped within 4 homogeneous habitat		X	4	25828	5.11	<.0001

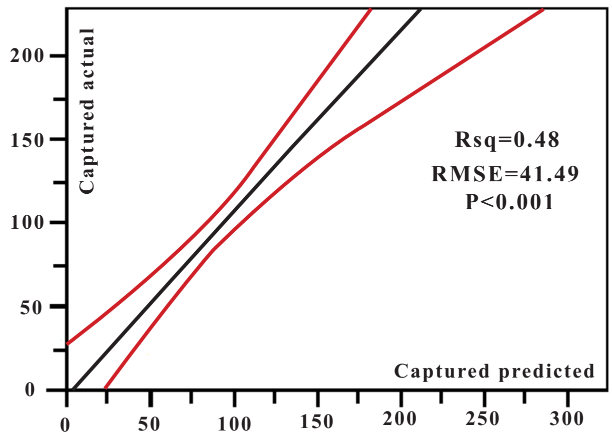

Fig. (2). Number of birds that can be removed as predicted from the summer census (habitat grouping and time not considered).

the opening of hunting season, animals moved to the free territories which survive to the hunt, tend to move again inside the PAs, pushed also by the hunting activity. Most of the young pheasants outside of the PA therefore, may be not counted during the summer census but can be present during the winter captures and till the next reproduction season; for this reason the plan for the captures in the winter period is of the strongly conservative type. It's important to emphasize that in the 30 PAs assigned to the maintenance and increase of the wild pheasant populations also the male/female ratio, substantially constant (1:1), is strongly unbalanced in favour of the males if we consider the pheasant polygamy. The reasons for these parameters of density and demography can be different and certainly interconnected to each other. We can assume, among the main ones, the spring impact of the predators and of the agricultural activities on the brooding females and the wrong management of the capture: more females than males are often regularly captured and therefore move beyond the PAs, to support the pheasants natural reproduction in the free hunting areas.

How Much Surface, at Least, should be Sampled Inside a Protected Area Surrounded by Hunting Areas?

The results shown in the Fig. (**1**) confirm what has been suggested by Italian researches [14] for the pheasants flush counts census, about the necessity of sampling at least 10% of the total surface of the protected area to have a reliable estimate of the natural population. In fact the estimate proves to be unreliable in smaller sample areas (negative correlation between percentage of surface monitored and esteemed density by the census of the population). It is clear that if the census surface is bigger the population consistency estimate is always better. This is also suggested by the persistence of a certain slope of regression line between the census surface percentage and the estimated total consistency of the population, even if statistically not different from zero (right side of Fig. **1**). The problem of the choice of the total surface to be submitted to census must however be related also to the total cost, in terms of labour and time required for the operations on the field. The technical indication of the Italian National Institute for Wildlife [6] is to census the pheasants in sample areas not lower than 20% of the surface to be monitored (the double surface of that suggested by [14]), in our opinion, this is difficult to be proposed in management practice. These grater surfaces, even if theoretically exemplary, in fact, does not lead to a significant improvement in the estimated data, doubling the census surface within the same day and, consequently, doubling the costs of the operations or reducing the efficiency of the flush counts. However, in addition to the least three or four representative sample areas of the various PA environments, it should be interesting to submit to the flush counts census for the future, when possible, also some area outside the PA.

The Most Important Single Demographic Parameter to the Harvest Plan

Table **2** shows that, in the case of the use of a single demographic parameter to estimate the number of pheasants to be captured, the best parameter to be chosen remain the total number of estimated pheasants in the PA (R^2 = 0.76 for the densities and R^2 = 0.81 for the absolute values, covariated by the measured PA-surface). The comparison of the simple linear regressions between the census data (expressed as density or absolute number covariated by the surface) and the density of the captured pheasants show clearly that, even if density is the commonly used parameter by the game management officers, it must be abandoned in favour of the absolute counts covariated by the PA-surface (Table **2**). This last way to calculate the consistency of pheasants , in fact, improves the precision of the estimated data, without any increase in the costs.

Big or Small Protected Area for the Pheasant? The Importance of the Surface

Another important consideration regards the dimensioning of the protected areas. In our experiment the PAs with smaller surfaces, which have the characteristics of the longer perimeter incidence and the consequently bigger natural dispersion, seem also to show bigger captures: the number of pheasants captured per 100 ha (Table **2**) is influenced by the total surface of the protected area, in fact, the increase of the surface-unit results in the increase of less than one of the captured-pheasant-unit (b values always lower than 1, between 0.61 and 0.75). This result may not contrast with the better theoretical outward dispersion of the animals, which should bring to a decrease of density inside the protected areas if we consider the tendency to the seasonal movements of the pheasants, from and toward, the PAs. For this last reason the smaller protected areas should allow also a better use of the surrounding hunting territories, at least outside the hunting season. On the other hand, to reach a minimum number of animals which can be relocated from a single protected area, sufficient to justify the management costs, it is indispensable to increase the surface to a minimum "economical" value, even if it may act in a less than proportional way on the increase of the captured pheasants. The increase of the PAs over the minimum "economical" value is however negative and over certain dimension, is affected also by managerial and organizational factors which intensify and weigh negatively on the increase of the protected surface.

Stepwise Selection of the Population Parameters: The Pheasants Harvest Plan Formula is Only a Starter

The results in Table **3** have shown how the number of estimated females and young, with the surface of the protected area, are the best parameters to evaluate the number of pheasants which will be captured in the next winter. Of course two other parameters were selected by the model: similar PA and year; they have an important habitat typology (the first) and temporal (the second) significance. We could have assembled the different PAs, previously, establishing our groups on the theoretical pheasant productivity, based on the habitat similarities between the different PAs [6,15,18]. The use of the stepwise selection of the different parameters, however, automatically groups the different PAs on the basis of the real pheasant productivity and, consequently, on the habitat similarities between the different PAs. Even if the statistical grouping, based on the data of several years, mainly overlaps itself to the theoretical habitat grouping, some areas are classified differently from the theoretical grouping. The existence of other, even if unidentified, important factors which influence the wildlife reproduction of the pheasants are so suggested to the game management officers. The same considerations can be done for the temporal effect. Weather conditions, and other variables, known or unknown, linked to the different years, in fact, deeply influence the reproductive traits and consequently reduce the percentage of variability explained by a general model [19-23]. The equation product (total number of pheasant to be captured = -10.3 + 0.15* total number of female pheasant estimated in the PA + 0.14* total number of young pheasant estimated in the PA + 0.04 total surface of the PA) was useful to determine the parameters to measure/estimate but it should only be used as a general starting plan limited to the Mediterranean area. In fact, the starting model should be contextualized towards the local realities where the pheasant management is carried out by the inclusion of the habitat diversity and of characteristics of the summer weather. In our example the generic model increased from $R^2 = 0.48$ to $R^2 = 0.66$.

CONCLUSIONS

The analysis of the capture data and the demographic parameters census in the PAs of the LWM-Fl, has given some important suggestions for the correct management of the wild pheasant populations in the no hunting areas surrounded by hunting areas.

The 9-10% of the total protected area must be regularly submitted to the flush counts census to determine the density and the fundamental demographic parameters of the pheasant populations. The number of adult males estimated in the summer census is not critical for the captures of the next winter. The number of the estimated females and offspring with the total surface of the protected areas (not the densities) are the best parameters to predict the number of animals which will be captured in the next winter. Since the number of adult males is not critical for the captures of the next winter, the increase of the males captured should be suggested. However, the males captured in excess, should not be relocated outside in the hunting areas (to leave unchanged the demographic population balances) but they might be used as reproducers, to improve the quality of the captive reared pheasants.

The general model we have found to predict the captures of pheasant inside the protected areas surrounded by hunting areas should be used only as a starting step for the correct management of the pheasants. In addition the model should be used only in Mediterranean habitats (low-hilly areas, high-hilly areas and plains with intensive cereal crops, olive-groves, vine-yards or pastures) with PAs between 297 and 1385 hectares. Finally, the probable seasonal movements of the pheasants, from and towards the PAs in relationship to the hunting season, suggest to submit to census also some area surrounding the PAs, since the flush counts census cannot be proposed in management practice during the hunting due to the lack of hunter volunteers.

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