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Research Paper

Agriculture: From a development perspective to Animal Resource Domestication.

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ABSTRACT:- Animal Resource Domestication (ARD) is recognised as a complex process through which humans transforms zoological entities into livestock. However, its value in the development of agriculture still awaits substantial exploration. Major aspects of ARD involve the initial confinement of desired animals of wild origin to human-controlled environments and the later artificial breeding of such animals for selected traits. Animals that are subjected to series of selection inherent in the domestication process exhibit profound changes in behavioural pattern, increment in growth-related parameters and improvement in reproduction-related functions. As captive animals experience changes in their physiology and becomes increasingly docile towards humans so also they progress into becoming *livestock* that are highly productive. These stages or *Animal Development Levels* provide clues to the development of sub-sectors of livestock agriculture and inform the postulations about the relationship between ARD and the development of agriculture.

KEYWORDS:- animal-development-levels, animal-livestock relationship, animal selection, human-animal interactions, livestock development

I. INTRODUCTION

Animal Resource Domestication (ARD) has close ties with the development of livestock-based agriculture. It explains the profound differences between the behavioural pattern of animals of wild origin and their domesticated counterparts [1]-[7]. Animal Resource Domestication (ARD) is also known to have facilitated the development of consistent growth pattern in domestic animals as well as improved reproduction-related functions [8]-[13] . The emergence of breeds of domestic animals that are highly productive gives credence to the fact that the pathway to sustainable production of animal products lies in the domestication of valuable animals of wild origin. As a result, a number of initiatives aimed at domesticating animals of wild origin have been proposed , still in progress or recently completed [4]-[8],[13]-[16]. In the ancient world, similar domestication exercises of valuable food animals such as the bezoar (wild goat), the asian mouflon (wild sheep), the auroch (wild cattle), wild boar and the red jungle fowl, facilitated progressive increase in production leading to the demise of the earlier practice of their exploitation through hunting.

Several studies on the varied aspects of the science of Animal Resource Domestication (ARD) abound. Among the scientific investigations are those which place emphasis on certain aspects of domestication especially on the bio-geographical/ genetic origin of animals [17]-[29] or the evolution of distinct behavioural pattern in domestic animal[1]-[7] . Other studies direct attention towards the selective breeding of captive animals of wild origin and their genetic improvement which often results in the development of new breeds [13],[16],[30]-[31] . Many of these scientific investigations explore the different aspects of domestication such as the relationship between endocrinology and behavioural change in captive animals and the effects of genetic improvement on growth-related functions as well as on reproduction-related functions. In other words, these studies pay attention to ARD but the focus does not acknowledge ARD as a development process within the institution of production generally referred to as agriculture.

The dearth of information about nature of Animal Resource Domestication (ARD) as a development process within agriculture therefore calls for attention. Attention in the form of an examination of the significance of ARD to agriculture is likely to produce outcome that may shed light on the development foundations of agriculture. For this reason, the study explores the practice of Animal Resource Domestication (ARD) with the overall aim of understanding its role in the development of agriculture.

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II. ANIMAL RESOURCE DOMESTICATION (ARD): A SYNOPSIS.

Species of animals are known to inhibit habitats in different ecological zones and continents. Large numbers of omnivorous birds and few grass-eating mammals have been identified in certain regions of the earth [32]-[37]. From these sources, birds such as the red jungle fowl, omnivorous mammals like the wild boar and large herbivores such as the yak are known to be natives of Southeast Asia. The ostrich, roam antelope and African wild ass are endemic to the continent of Africa. Species of wild goat, sheep and cattle thrive naturally in habitats of Eurasia and the Indian subcontinents. Several species of other animals are endemic to distant continents and the new worlds as indicated by the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. The second largest bird the common emu, the brush-tailed rabbit rat and the kangaroo are among the notable fauna of Australia [37]. Likewise, animals such as the wild turkey, river otter and the American bison populate specific ecological zones of North America just as Muscovy ducks, guinea pigs and llamas are localized to certain regions in South America. Many of these animals have been found to be valuable food materials leading to their continuous exploitation and consumption.

There are now reasons to control the continuous exploitation of these animals as it is increasingly becoming a cause of concern. The situation is such that the rate of decline in the population of many species of valued animals is greater than the rate of growth which suggests that current practice of uncontrolled exploitation threatens their survival in the wild. This declining trend in population size and structure of animal species has been categorised into Extinct, Extinct in the wild, Critically Endangered, Endangered, Vulnerable and Near Threatened [37],[38]. Furthermore, an evaluation of animal species in the wild reveals the extent of decline in population of vertebrate animals as follows: over one-third of fish species, about one-third of amphibians and reptiles, over one-tenth of birds and one -fifth of mammals are threatened [36]. The scenario which is particularly grave for the ancestors and wild relatives of major livestock has been acknowledged by the Food and Agriculture Organisation (FAO) Report on the "*State of the World's Animal Genetic Resources for Food and Agriculture*". For this reason, the establishment of national parks , wildlife sanctuaries and protected areas are either being employed or proposed for the protection of wild relatives of cattle, goats, sheep, birds and other animals [32]-[37].

Conservation of animal species of wild origin generally plays an important role in sustaining the process of domestication. Scientific investigation on wild animals provide clues to the particular population or subspecies that were transformed into livestock and the degree of contribution of other relatives (if any) to the process of transformation [24]. More still, the presence of animals in their natural habitat assist in identifying behaviours which made them prime candidates for domestication and the changes to behavioural pattern that accompany the domestication event [1][2][3]. Generally, animals of wild origin that were transferred to artificial environment exhibit large gregarious social system, promiscuous mating system, low reactivity to humans or sudden changes in environment and fed on wide variety of food materials among other behavioural traits. However, the process of taming wild animals generally involves their confinement to artificial environments, allowing them to breed freely even in captivity and then selective breeding for desired traits [4]-[8],[13]-[16]. .

2.1 The confinement aspect of Animal Resource Domestication (ARD).

Confinement of animals of wild origin presupposes that they have been transferred to human-designed environments. Yet, the exact causative agent that facilitated the practice of confining animals rather than the usual practice of hunting them remains uncertain. Nevertheless, the transformation of wild resource to agricultural species is closely aligned with direct human response to changes in climatic conditions, distribution pattern of food organism and human population size [39]-[41]. From this perspective, a similar scenario in the form of a desire to secure the supply of preferred food animals may have lead to the practice of their conferment. However, certain behavioural characteristics define animals that were considered worthy candidates for confinement: non-aggressive response to humans, omnivorous feeding habit, adaptability to wide environmental conditions , promiscuous sexual behaviour among others [1][2][3] . These behavioural traits are exemplified in some of the most recent animal domesticates whose wild progenitors are still extant such as the Mongolian gerbil and Syrian hamster [6] [7]. In confined conditions, the vivid escape reactions which marks the gerbil in the wild begins to decrease just as the occasional biting habit during handling ceases in the course of successive generations [6]. Similar changes in the behaviour of successive generations of wild Syrian hamster have been reported when confined to artificial environment [7].

Interestingly, the changes in the behaviour of wild animals is closely associated to alterations in the function of the brain. Docility in tamed animals as an evidence of behavioural change is attributed to the modifications to the brains by several authors as brain size of domesticated rodents reduce by one-fifth, those of birds by about one-fourth, sheep also by one-fourth while that of pig is about one-third [42]. The relationship between brain-size reduction and the transformation of animals of wild origin is clearly demonstrated in wild cavies *(Cavia operea)* and domestic guinea pigs *(Cavia porcellus).* As the brain size of captive wild cavy

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gradually reduces in size so also their tendency to be aggressive begin to wean making them to display a more socio-positive behaviour towards members of the same population [4][5]. Furthermore, this generally positive attitude makes confined cavies undergoing domestication more dispose to courtship and sexual behaviours even though they show less attention to their surroundings. these changes to both brain size and behaviour of animals occur in confined conditions, yet there are evidences which indicate that the docility and other behavioural traits found in domestic animals may not have been the sole product of mere confinement exercises. For captive wild cavies reared in captivity for thirty generations without selection for tameness manifest the same behavioural responses as those found in wild-trapped cavies [5]. This is an indication that selective breeding is an essential aspect in the process of transforming animals of wild origin into their domestic equivalent.

2.2. Selective breeding/breed improvement aspect of ARD.

Selection of desired traits in captive animals is an important aspect of animal resource domestication (ARD) . Some traits are noticeable in the animals prior to their confinement or manifest themselves in the course of breeding in captivity. Traits that are commonly selected in the population of captive animals are not restricted to skin colour, body weight and growth rate. Artificial selection of colour trait is well demonstrated in the selective breeding of the pearl guinea fowl whose domestication is generally believed to have been initiated many centuries ago by the Romans and Greeks. The wild-type guinea fowl of dark grey-black ground colour dotted with white spot when selectively breed produce a variety of distinct plumage colours such as pearl, coral blue , white and dun [30] [31]. For instance, a cross between individuals selected for plumage colour from a population with dun coloured individuals produced offspring that were all marked by the dun colour. Similarly, a cross between individuals selected for the pearl-colour with dun coloured individuals (without pearl markings) produces a generation with all the individuals having the pearl-coloured plumage. This result is always the same for males of the pearl-coloured birds crossed with dun coloured females or for the males of the dun coloured birds crossed with pearl-coloured females [31]. Put simply, the outcome of the breeding exercise in the birds is a constant irrespective of the sexes of the plumage colour-type. But a cross between the first generation which are all pearl-coloured produced a generation with about three-quarter of the individuals having the pearl-colour and about one-quarter with the dun colour. However, selection for is a more complex process as the traits have a range of expression among individuals of a population. The differences in quantitative traits such as growth rate, body weight and food conversion among individuals of a particular population assist in the attainment of a certain measure of predictability (h^2)[43],[44]. the condition where h^2 is moderate to high often facilitate the selection of high-performing birds and other domestic animals [8],[45]-[48]

III. ARD: THE TRANSFORMATION OF WILDLIFE INTO LIVESTOCK.

A relatively few number of natural-occuring animals have been transformed into domestic animals. They include species of wild goat, sheep and cattle as well as those of birds aand pigs (see Table 1). The modification of the wild tendencies of bezoar lead to the emergence of the domestic goat , the asia mouflon develops into the domestic sheep and the auroch evolves into the modern cattle [17]-[24]. In a similar way, the taming of the wild boar results in the development of the domestic pig while the changes in the red jungle fowl produced the domestic chicken [25]-[29]. These events leading up to the development of major livestock occurred generally in three centres : the Fertile Crescent and other regions of Southwest Asia, China including other regions of Southeast Asia and the Andean region of South America [24]. Within these centres, the gradual but complex process of transforming captive wild animals occurred not less than 5,000 years ago [17][18][20][21][49]. Nevertheless, animals of wild origin are continuously being captured, confined and tamed whenever they are found to be beneficial to man. One of such relatively recent domesticate is the Japanese Quail whose modification into a livestock happened largely in the twentieth century [8],[47],[14]. Another animal of wild origin which is responding to series of human-induced selection in confined environments is the cane rat [11],[13],[15],[16],[49].

3.1 Japanese quail

The Japanese quail is a medium-sized bird which belong to the taxonomic group *Coturnix*. This bird that is scientifically referred to as *Coturnix japanicus* shares the genus *Coturnix* with other members such as *C. coromandelica* (rain quail), *C. delegorguei* (harlequin quail), *C. novaezalandiae* (Newzealand quail , believed to be extinct)and *C. pectoralis* (stubble quail) [37]. Descriptions of different aspect of the bird including external morphology, ecology and behavioural pattern have been reported by several authors [51][52][53]. From these sources, the uniform dark reddish-brown plumage of *Coturnix japanicus* appears to be altered at the breast region of female birds with pale feathers that are marked with dark spots. Generally, the bird is a ground-living species that are mainly distributed across the bushes and agricultural fields of East Asia especially Japan,

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China and South Korea. Nevertheless, this species of quail are known to breed in sites that extend from turkey to other parts of Europe which are outside their biogeographical origin. More stil, they feed mainly on parts of different types of grasses, variety of insects and other invertebrates usually at the beginning and end of the day. Wild quail breed seasonally from may to October every year, show low copulation and lays few eggs usually at night. Generally, the bird makes distinct sound otherwise known as vocalization when feeding and during courtship.

The vocalization of quails of wild origin may have been the primary trait that necessitated its confinement. However, the exact period when capture and use of quails as song birds started is yet to be resolved as it is estimated to be between 900 to 1500 years ago [51][52]. Yet, a pioneer account of the process of taming quails reveals that it involves the capture of the bird from the wild, confinement to an artificial environment, and overcoming their wild nature by kind treatment [14]. In captivity, the frequency of vocalization of wild quail gradually increases in the same way as their aggressive/fighting behaviour increases [53]. Differences in a number of traits especially those of growth rate and body weight are noticeable among individuals in populations of quail produced in captivity. Artificial selection for these traits based on the measure of heritability produced birds with faster growth rate, more efficient in converting feed to body weight and higher body weights [8][12] [47] [48][54][55]. The results which improve in each successive generation affirm selective breeding as an integral part in the transformation of wild animals into their domestic form. Indeed, these improvements in successive generations of captive quails have transformed the earlier subsistence practice of keeping quail as song birds into a thriving poultry industry within a century .

3.2 Cane rat.

The cane rat is a rodent of the taxonomic group *Thryonomys* with two known species: *Thryonomys swinderianus* and *Thryonomys gregorianus* . This relatively small mammal has a combination of reddish brown-grey hairs and weighs between 2 to 6 kilogram depending on the sex and species [15][56]. Both species are native to Africa and inhibit the vast grassland which extends from the West of Africa to its southern part [57][58]. Aspects of morphology, feeding habits and reproduction pattern in cane rat have been described by a number of authors [15][58]. From these sources, the animal is known to either thrive on the abundant supply of grasses or on canes found in agricultural fields hence their common names grasscutter or cane rat. This rodent is most active during the night as it starts feeding from dusk into the nights and later in the early hours of the day. Cane rat is believed to reproduce all year round but the period when young cane rat are most abundant coincides with those seasons when food materials are aboundant. The carcass of cane rat contains high quality protein, low fat and excellent curinary qualities that makes it a preferred meat by indigenous people over those of livestock [56][57][58].

The status of cane rat meat as the preferred meat may have contributed to its confinement for the purposed of domestication. In captivity, the cane rat grows faster on diet with high levels of crude protein and relatively lower crude fibre. Indeed, the growth performance of confined cane rat on selected feed ingredients indicated a more efficient conversion of feed to flesh, higher weight gain as well as better carcass quality [50]. Interestingly, the cane rat which is nocturnal in the wild begin to fed during the day after a period of acclimatization to confined conditions as revealed in most of the studies. Equally of interest is the litter size which exceeds six in cane rat under enclosure [9][11][15]. As a result, large size of cane rat populations containing individuals from more than one generation have be established in confined conditions. However, genetic analysis of the variations in production traits within the established population reveal a moderate to high heritability value for body weight and growth trait as well as the existence of a moderate to high correlation between them [13][16]. These findings are likely to facilitate breeding programmes as they indicate that artificial selection will be effective in improving the performance level of the cane rat[13][16][43][45]. A prospect for fast genetic gain in the improvement of body weight traits therefore exist since the breeding estimates are similar to those found in other livestock [13][16][46]. For the reason, there is now an anticipation of long term genetic evaluation of the cane rat that would eventually lead to its complete domestication. The successfully transformation of the cane rat into a livestock is likely to facilitated its dispersal to other part of the world and confer a new global status on this animal species that is native only to Africa.

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TABLE 1. Selected animals of wild origin and their domesticates as livestock

ANIMALS OF WILD ORIGIN	GENUS/ SPECIES ESTIMATE & MAIN SPECIES	NOTABLE SUB-SPECIES	PROGENITORS OF DOMESTICATE	DOMESTICATED SPECIES
RED JUNGE FOWL* (Wild fowl)	*Gallus* 4 main species *Gallus gallus*	*Gallus.g.bankiva* *Gallus.g.gallus* *Gallus.g.jabouillei* *Gallus.g.murghi* *Gallus.g.spadiceus*	Sub-species of *Gallus gallus* in different locations	*G. domesticus*
PIG* (Wild pig)	*Sus* 1 main species *Sus scrofa*	*S.s. andamanensis* *S.s. aruensis* *S.s. babi* *S.s. ceramensis* *S.s. enganus* *S.s. floresianus* *and about 10 other sub species.*	Sub species of *Sus scrofa* in the different regions	*S. s. domesticus*
BEZOAR* (Wild goat)	*Capra* 8-9 main species *Capra aegagrus*	*C.a. aegagrus* *C. a. blythi* *C.a. chialtanensis* *C.a. cretica* *C.a. turcmenica* *C.a. pictus*	*C.a. aegagrus*	*C. a. hircus*
MOUFLON* (Wild sheep)	*Ovis* 6 main species *Ovis orientalis*		*Ovis orientalis*	*Ovis aries*
AUROCH* (Wild cattle)	*Bos* 1 main species *Bos primigenius*	*B.p. primigenius* *B.p.opisthonomous* *B.p. nomadicus*	*B.p. primigenius +* *B.p.opisthonomous* *B.p. nomadicus*	*Bos taurus* *Bos indicus*

*indicates source(s).
RED JUNGE FOWL*:[25],[26][29][35]
PIG*: [24];[27][28][35][37]

BEZOAR *: [21][22][23][24][35]
MOUFLON*: [19][20] [35][37]
AUROCH *:[17][18][24]

IV. ARD IN THE DEVELOPMENT OF AGRICULTURE.

Animal Resource Domestication (ARD) initiates and sustains the development of animals into advanced forms that are well suited for agricultural production. On the one hand, ARD transforms animals of wild origin into docile entities that constitute the founding populations/stock of animal-based agriculture. On the other hand, it facilitates the utilization of the genetic potentials of captive animals leading to the development of livestock.

Domestication of animals in confinement allows their wild nature especially behavioural pattern to be tamed. The pattern of behaviour in wild animals is conditioned by both climatic and biotic factors. In a particular way, the prey-predator relationship impact heavily on the evolution of distinct set of behaviour in animals of wild origin. Quick Escape Response or Defence Mechanisms are developed by the animal which is haunted for food (prey) against animals that haunt (predators). These sets of behaviour in wild animals have been tempered through the provision of predator-free environment, adequate feed ingredients and selection of desired traits within captive populations. Some of the captive animals whose behavioural pattern changed profoundly during the process of domestication include the guinea pig, Mongolian gerbils, Syrian hamster and Japanese quail [4]-[7],[14],[53] . The frequency of vocalization in quails increases in confined conditions making it a suitable song bird. This is an improvement in comparison to the less frequent vocalization attempts in their natural habitat so as not to attract the attention of predators [53]. In a similar way, a docile attitude is manifested by captive Mongolian gerbil and cavies in the course of successive generations which is in contrast to their natural vivid escape reactions and occasional biting habit [4]-[6]. This relatively recent feat of transforming rodents from wild to domestic animals is indicative of similar transformation in ancient

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domesticates such as goat, sheep and cattle. However, the process of transforming wild animals into their domestic form is enhanced greatly by artificial selection for tameness [5].

Artificial selection for desired traits drives to completion the transformation of captive animals into livestock. Selection increases body weight of captive animals in the course of their transformation into domestic animals. In nature, the full expression of the growth potentials in animals are not fully expressed as may be deduced from their comparatively poor performances [6],[53]. However, series of selection for growth-related traits in captive population have lead to increases in body weight. For example, the average body weight of Japanese quail selected for body weight improved significantly and in some cases increased by about 300% over ninety successive generations [8],[12],[47],[48],[54],[55]. Selection for growth-related traits have also lead to the genetic improvements of other livestock or would-be livestock [13],[16],[45],[46]. Similarly, selective pressures inherent in the domestication process improve the reproductive performance of captive animals to optimal levels: the Japanese quail in artificial environment lays hundreds of eggs with superior egg indexes when compared to wild quail that lays few eggs and whose egg-laying habit is seasonal [53]. Selection for plumage or skin colour and other qualitative traits serve to compliment the genetic improvement in body weight and other quantitative traits. Selection in wild guinea fowl based on the knowledge of expression pattern of certain genes has produced colour varieties of the bird in successive generations [30],[31]. Royal purple, lavender, coral blue, dundotte, dun, porcelain, opaline, white-breasted pearl splashed, white-breasted purple are some of the many colour varieties that have been artificially selected from captive population of guinea fowl. The application of similar knowledge is instrumental to the differentiation of breeds of domestic animals based on skin or plumage colour: white plumage for meat breeds of birds such as broilers, brown/black plumage for egg-laying breeds, white fur for wool-producing breeds of sheep like the merino and black-white colour for dairy breed of cattle such as the famous Holstein-Friesians.

The significance of Animal resource Domestication (ARD) in agriculture presents a human-driven phenomenon that embodies different levels of animal development. Generally, the varied species of animals of wild origin are remote from the effects of human influence; the main species of red jungle fowl, wild pig, bezoar, mouflon and auroch are all in the primitive or simple state and may simply be termed *animals.* Animals-*zoological entities in their primitive state*- manifest behavioural pattern that is typified by vivid escape response and are relevant only as an integral part of the ecosystem. From a development view point, all animals with untamed behavioural pattern and "ecosystem –based" function are in the *Primary Level of Animal Development,* that is, a level where human-animal interaction is either minimal or non-existent.

Animals are subjected to intense evaluation by humans in the event of a contact and in the course of interaction. Some species of animal especially large birds and grass-eating mammals are found to be valuable for food purposes (Table 1). Such animals that are exploited for meat or other purposes are of direct value to humans and so valued as "utility animals" or *animal resource*. At the stage of exploitation, an animal resource retains its wild behavioural pattern as it still remains outside the direct control of humans. But, its function is moderately enhanced as it now transcends the "ecosystem-based" aspect of its primitive state to include a "utility-based" dimension. In terms of development, an animal resource has evolved from the the primitive state of *Primary Level of Animal Development* to an intermediate state or *Secondary Level of Animal Development*. Put differently, the *Secondary Level of Animal Development* is the level where human-animal interaction is based on purpose; a level where mere animals gain the status of animal resource.

Animal resource develops further when transferred from its natual habitat to human-controlled environment. Table 1 indicates that only *Gallus gallus* from among the four species of wild fowl were confined to artificial environments. *Capra aegagrus* from the 8-9 species of wild goat were transfered from its natural habitat to artificial environment. Again, *Ovis orientalis* from the about 6 main species of wild sheep was subjected to confinement. Interestingly, when captive population of *Gallus gallus*, *Sus scrofa, Capra aegagrus , Ovis orientalis,* and *Bos primigenius* when selected for desired traits such as body weight and tameness developed progressively into domestic chicken, pig, goat , sheep and cattle respectively (Table 1). Furthermore, the docility of captive animals allows for the expansion of their "utility-based function" to optimum levels through genetic improvements of desired traits. As a result, animals previously haunted for meat were transformed into meat-producing animals while those exploited for wool are tamed into wool-producing animals. Accordingly, the transition of animal resource into livestock is simultaneously a progression from the intermediate state or *Secondary Level of Animal Development* to the advanced or *Tertiary Level of Animal Development.* Stated alternatively, *Tertiary Level of Animal Development* is the level at which captive animals are conditioned to perform particular function(s) and are no longer haunted but reared.

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V. CONCLUSION

The relationship between the development of agriculture and Animal Resource Domestication (ARD) is the central theme of the study. Investigations into the principal aspects of the domestication process (ARD), the most relatively recent success in domesticating captive wild animals as well as on-going domestication programme were strategic to achieving the main aim of the study. The central theme of the study allows agriculture to be viewed as an institution within which ARD is a development process; a view that may be summarized as follows:

- Agriculture is a human-animal interaction through which animals of wild origin are tamed and their genetic potentials rationally explored for the purpose of livestock production thereby highlighting the brilliance of the human agriculture genius.
- Agriculture is a *development institution* within which the livestock sector is a *development structure* formed through the *development process* ARD.
- The *development process* and *the development structure* suggest the existence of a *development design/ architecture* within agriculture.

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