**Consanguinity and endogamy of a Northeastern Algerian population (population of El-Kala)**

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**ARTICLE INFO**

**ABSTRACT**

Human population's reproductive system is usually determined by socio-demographic and cultural variables, it is also depending on ethnicity, religion and geography. The interest of studying this system is justified by the role of mate selection on the genetic structure of the family, on the gene's pool evolution inside a population and on the fecundity and fertility of the couple as well as the human's morbidity and mortality. In the other hand, research among Arabs and worldwide has indicated that consanguinity could have an effect on rates of congenital malformations. The main impact of consanguinity, however, is an increase in the rate of homozygotes for autosomal recessive genetic disorders. Worldwide, known dominant disorders are more numerous than known recessive disorders. Consanguinity is a deeply rooted social trend among one-fifth of the world population mostly residing in the Middle East, West Asia and North Africa, Algeria is a Muslim Arab North-African country where anthropological studies of different populations are rare and the few estimated frequency of consanguineous marriages were obtained from the overall national statistical studies. Therefore, this type of marriage in Algeria, in general, and in the North East in particular is still subject of controversy. In the present work, we studied the inbreeding and its evolution in the North-eastern population of Algeria (The district of El-Kala previously known as "La Calle"). We determined the type and the structure of this society and the effect of the type of habitat on the matrimonial choice. A genetic study was conducted among a resident that lives in five different areas: (BOUGOUS, MEXA, RIHANE, FRINE (BOUTELLAH ABDELLAH) and EL MELLAH (the old Calle) aged from 18 to 84 years old. Our survey showed that the population of El-Kala is endogamous and that the marital attitudes' change between our three studied generation; Generation of studied couples GSC husband / wife (H / W) (the parents of the index case); Generation of husband's parents GHP Paternal Grandfather / Paternal Grandmother (PGF / PGM) and Generation of the Wife's parents GWP: Maternal Grandfather / Maternal Grandmother (MGF / MGM). The average rate of endogamy therefore is very high, while the average rate of inbreeding in this population is low; the average rate of endogamy for the three generations (GSC, GHP and GWP) is high with a low degree of consanguinity. We also found that the type of habitat (rural or urban) does not influence the structure of our population. In perspective, we propose to perform more investigation in order to identify factors increasing the endogamy in the Northeastern Algeria.

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**INTRODUCTION**

Mankind has known throughout its history several types of wedding, set by the predominating relationships and social structures, this is why, most anthropological researches studying human societies have focused on the family kinship. Those researches revealed that there is not only one type of marriage but it differs from one society to another; depending on socio-economic and cultural factors existing in those societies and the dominant values according to the function performed by the bonds of marriage [1].

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Inbreeding is a specific case of matrimonial ties between spouses. The frequency of inbreeding depends on the population size, geographical location and isolation and on the existence of any socio-economic and cultural practices that promote or prevent a certain type of relationship. It is depending also on ethnicity and religion [2,3,4].

Consanguineous marriage refers to union between individuals who share at least one common ancestor. The union with the patrilateral parallel cousin is the first possible form of family endogamy [5,6,7].

In Arab societies, all categories of cousins wed themselves [8]. Some studies conducted in the Arab and Islamic world showed that family endogamy is still a very important feature of alliances contracted further in Jordan, Palestine, Syria, Iraq, Kuwait, Saudi Arabia, Kurdistan, Iran, Pakistan, Egypt, Sudan, Lebanon and North Africa (Tunisia, Morocco and Algeria) [9,10,11,12,13,1].

Consanguineous marriage is traditional and respected in most communities of North Africa [14]. Anthropological studies of different populations in Algeria are rare and the few estimated frequency of consanguineous marriages were obtained from the overall national statistical studies [1]. Therefore, this type of marriage in Algeria, in general, and in the North East in particular is still subject of controversy.

It is agreed that consanguineous marriages affect health hence our interest to study and know the type of the population of El-Kala. There are several studies that show that marriage between cousins is responsible of several diseases such as heart disease, congenital abnormalities of, deafness, mental retardation or even in cancers [15,16,17,7].

The objective of this present work is to study the inbreeding and its evolution in a population located in the North-Eastern part of Algeria: The City of El-Kala.

MATERIALS AND METHODS

Definitions and Measures:
Inbreeding:
is a family model characterizing union between individuals belonging to the same category. This model leads to a social immobility of individuals, or even, the genetic isolation of the reproductive group compared to the general population. In most studies, the category corresponds to the regional origin of the spouses; it has been studied in various Arab and non Arab countries of Arab and Western world by measuring the inbreeding rates. The intensity of inbreeding depends on kinship, geographical distance or social stratification [18].

However, there are different types of endogamy: spatial endogamy, intra-ethnic endogamy, intra-Community endogamy, intra-religious endogamy, family endogamy (consanguinity), etc. [18].

The geographical or ethnic endogamy can increase inbreeding especially in small groups where there is a greater chance to gather gametes carrying the same genetic information. [19].

Individual inbreeding coefficient Fi:
The inbreeding coefficient is the probability that two homologous genes are identical by ancestry at any locus of an individual T [19]:
\[ F_i = \sum \frac{1}{2^{p+m+1}} (1+F_{Ai}) \]

\*p: number of generations that separate the father of the individual I from the common ancestor Ai. \*m: number of generations that separate the mother of the individual I from the common ancestor Ai. \*F_{Ai}: the inbreeding coefficient of the ancestor Ai.

Related Inbreeding Coefficient:
The related inbreeding coefficient Ca is used for the population’s analysis [20]:
\[ Ca = \frac{1}{8} R_{deg} + \frac{1}{16} R_{CG} + \frac{1}{32} R_{CI} + \frac{1}{64} R_{Cig} \]
\( R_{deg} , R_{CG} , R_{CI} , R_{Cig} \) are respectively the frequencies of unions between: double first cousins, cousins and uneven cousins.

Methods used to compare the endogamy and consanguinity rates:
The convergence of the normal law is used. We assume that the mean of a sample selected from any population follow approximately a normal distribution when the sample size is large enough (n≥ 30), allowing to compare percentages.

When we obtain a p observed frequency on a sample of size n taken from a sufficiently large population, we can calculate the z-score:
\[ \varepsilon = \frac{|p' - p^*|}{\sqrt{(pq)/n}} \]

\* \( \varepsilon \) represents the standard deviation of the corresponding normal law. * p: is the observed frequency. * po: is the theoretical frequency. * q = 1 - p. * n: sample size.

The p value is 5%.
Comparison between two observed frequencies:

Chi-2 test is used when theoretical statistics are larger than 5. The exact test of Fisher is used when at least one of the theoretical statistics is less than 5.

These tests are recommended by statisticians for this type of analysis.

Population and Methods:

Studied Area:

This study was performed at El-Kala city formerly known as "La Calle". His name has always evoked red coral, the most beautiful of all the seas by the geographer El Idrissi (1150).

The surveys were conducted in five (05) different areas: Mexa, Bougous, Rhiane, Frine "Boutella Abdullah" and El Mellah "old Calle" (Figure 1). Geographically, El-Kala, Common Willaya EL-TARF, is located at 86 km East far from Annaba; it is on the road to Tabarka and Tunis, Tunisia. El Kala is a small coastal city that has about 24,189 inhabitants according to the latest estimation given by the Algerian National Bureau of Statistics (http://www.ons.dz/IMG/pdf/armature_urbaine_2008.pdf). It was created by the French during their colonial period in Algeria.

The El-Kala region relies on the entire territory a large number of historical sites that contain countless vestiges of extinct civilizations. Within the framework of a cooperation agreement between the Italian University of Trento and by the National Agency of Archaeology, excavations conducted by Professor Mariette de Vos and Dr. Reda Attoui for the development of the archaeological map of eastern Algeria (Project 2003-2007) found that the prehistoric heritage, attested by the discovery of stone tools, dating back to the Lower Paleolithic (~1.8 million years - 100,000 years). The megalithic remains (dolmens, grinding wheels, pressoirs, sarcophagi, tombs) scattered throughout the territory, especially in the mountains of Bougous of Segleb and Jebel El Ghorra testify to the presence of a proto-historic and ancient civilization. This is also the area of the country that gave the greatest volume parts for punique-Libyan period. [21].

The few significant monuments representing the medieval period are located in the region (Genoese fortress located near the beach of Cape Segleb and Fort Mill built by the Ottomans in the hills of El-Kala Port).

In ancient Roman times, the town was named El Kala Tuniza. She was baptized Mers El Kharez (port Trinket or port pearls) by the Arabs, by deformation becomes Calle de Marsacarèse by the French, and finally La Calle or El-Kala in Arabic (a term synonymous with marine landing stage) (http://annaba.net.free.fr/html/kala.histoire.htm)

Studied Population:

Our study is performed on indigenous people (two generations at least). Selected individuals are unrelated and seems to be healthy. A genetic study was made on 80 people aged from 18 to 84 years old and we have performed this study using a questionnaire. We have proceeded in two different ways to gather the information we needed: first we did a door to door survey in the old Calle while we made a public notice in public health centers of the other municipalities.

The Questionnaire:

The survey was conducted using a pre-established questionnaire. People willing to answer that questionnaire must have their parents and their four grandparents originated from El-Kala.

We performed by ourselves those interviews.

The questionnaire included questions relating to the following:

a- anthropometric parameters: weight and size of the index case.

b- Socio-demographic parameters: sex, age, marital status, residence, geographic origin of the index case and geographic origin of parents, grandparents (paternal, maternal) of the index case.

c- Clinical features: Personal and family history.

d- Other parameters: The nuclear family of the index case (child), the nuclear family of the index case (marital), the nuclear family of father and mother's index case. The inbreeding of the index case, of the father and the mother. Relationship of the couple, parents and grandparents.

The genealogies were reconstructed on the basis of the oral tradition which depends particularly on the memory capacity. This retrospective method has the disadvantage of not having always a very reliable data, knowing that the memory of people, especially older ones, is not very reliable. However, this method is the only way to obtain information about the degree of relationship between spouses, parents and grandparents.

Our study focused on the following generations:

- Generation of studied couples GSC husband / wife (H / W) (the parents of the index case).
- Generation of husband's parents GHP Paternal Grandfather / Paternal Grandmother (PGF / PGM);
**Statistical Analyses:**

Data entry and statistics were registered using Microsoft Office Excel 2007. The STATA statistical software (version 2011) was used for all statistical calculations: inbreeding, endogamy and their comparisons.

**Results:**

**Demographic:**

49% of the 80 peoples interviewed in this study live in rural area whereas 51% in urban areas. The description of samples according to the type of environment is shown in Figure 02.

**Endogamy:**

The distribution of various endogamous and exogamous marriages of our 80 individuals for each generation (GSC, GHP and GWP) is given in Table 01.

The rate of inbreeding is high for GHP and GWP, which are respectively 99% and 92% as opposed to GSC which is 61%.

**Comparison of intergenerational inbreeding rates:**

The comparison of the inbreeding rate between the 3 studied generations (GSC, GHP and GWP) is given in Table 02.

The comparison of the endogamy rates between index case VS Father and Index case VS Mother showed a non significant difference $p > 5\%$, whereas the difference is significant ($p < \alpha$) for Father VS Mother.

**Inbreeding:**

The distribution of consanguineous marriages of our 80 individuals interviewed for each generation (GSC, GHP and GWP) is given in the following Table 03.

According to our results, the inbreeding rate is low for the three studied generations. It is about 6% and 4% respectively for GHP and GWP and 11% for GSC. However, it is increased for the GSC.

The distribution of the different classes of inbreeding for each of generation considered (GSC, GHP and GWP) are shown in Table 04.

**The coefficient of consanguinity:**

The inbreeding coefficient for each of the considered generation (GSC, GHP and GWP) is given in Table 05.

**Comparison between the Inter-generational inbreeding Rate:**

The comparison of inbreeding rate between the three studied generations (GSC, GHP and GWP) is given in Table 06. It seems that inbreeding increases in the (GSC) with an inbreeding coefficient of 0.47 compared to the generation of the Husband's Parents (GHP) which has a coefficient of 0.25 and the generation of the wife's parents (GWP) with a coefficient of 0.69.

The homogeneity test showed a no significant difference ($p < 5\%$).

**Comparison of inbreeding rate in the national and international territory:**

The practice of consanguineous marriage is very widespread in the Arab world, the frequencies of consanguineous marriages in Algeria and in various Arab countries are shown in table 07.

**The effect of habitat type on marital choice:**

**Endogamy:**

The correlation between the type of habitat and the endogamy of the index case is shown in table 8. According to the $\chi^2$ test Person, the habitat type has no effect on the Endogamy of El-Kala's population ($\chi^2$= 0.610, $\alpha = 5\% = 1.96$ no significant differences). It should be noted that we have not taken into account the 'unspecified' class of endogamy in our statistical analysis.

**The Inbreeding:**

The correlation between the type of habitat and the inbreeding of the index case is shown in table 9. According to Fischer's exact test the habitat type has no effect on the inbreeding of El-kala population.

**Discussion:**

The practice of consanguineous marriage is still maintained in the Arab world and the Maghreb countries [22]. In Algeria, according to a national survey conducted by the National Foundation for Health Promotion and Research Development (NFHPRD) in 2007 consanguineous marriages were very common with a national average of 38.08%.
In the present work, we studied the inbreeding and its evolution in the population of El-Kala located in the North-Eastern part of Algeria. We were expecting to find an inbred population because of the different genetic diseases that exists in that area, the most common of which is sickle cell anemia (SCD).

The analysis of the endogamy rate showed a strong endogamy in the studied population. However, and although its rate remains considerably high, it seems that endogamy is declining in the generation of the studied couple (GSC) 61.25% compared to the previous generations that have an average of 95.44%. The difference is statistically significant.

Our analysis showed a low inbreeding rate in our studied population but this rate has increased for the generation of the studied couple (GSC) with a rate of 11.54% while it was only 6.06 and 4.11 for the previous generations, respectively the generation of the Husband's Parents (GHP) and the generation of the wife's parents (GWP). This low rate of the consanguinity can be explained by the decrease of the endogamy rate as mentioned in Chalbi and Zakaria's [24] and also Lathrop and Pison (1982) where they explained that inbreeding unions are generated by any kind of endogamy.

At the scale of Algeria, the consanguinity rate remains high, the average rate is 38.80% where the highest rate of inbreeding was observed in the East at Bir El Ater (in Tebessa), with a rate of 88%, while the lowest rate was recorded in Oran city, located in the far west of Algeria, with only 18.5%. Another study was conducted in the region of Oulhaça, in the far West of Algeria [1] showed almost the same results with a consanguinity rate of 36.07%. Our results showed that El-Kala population harbours the lowest rate of consanguinity (11.54%) in Algeria.

At the Arab region scale, the inbreeding rates are significantly high 31.79% in Giza [25], 68 % in Egypt (Mokhtar, Abdel-Fattah 2001), 51–58 % in Jordan [27,28,29], 52 % in Qatar [30,31], 50 % in the United Arab Emirates [32], 54 % in Kuwait [33,24], 58 % in Saudi Arabia [35], 25% in Lebanon [10], 40 % to 47 % in Yemen [36,37], 50 % in Oman [38], 20,83 % in Tunisia [39] and 57,3% [1] while In Morocco 19.87% over the period 1982-1992 (11) and26,03% [25].

Consanguineous unions are also frequent in many Non-Arab Middle Eastern countries such as Turkey with 21.2 % [40] and Iran with 38.6 % [41].

Many authors have noticed the preference of the intermarriage among Arabs, there is a great preference to gather the cousins (degree of relation very close). This model of family is still very preferred in the Middle East and the Maghreb countries and it stays also privileged in the Arab-Muslim society despite the modernization [11]. Algeria is following her neighbors, according to a study conducted by the NFHPRD and to our survey this kind of union is preserved.

In our study, among the 80 people that we’ve interviewed 49% lives in rural areas and 51% in urban areas, we’ve noticed that the type of habitat (rural or urban) does not affect the marital choices in the different generation. The increasing of the degree of endogamy in this population could be due to other factors related to the socio-economic development of the population.

Our results agree with those of Talbi and al., [11] in the Morrocan population. While in the studies conducted by Sidi Yakhlef and Aouar [1] at Oulhaça population, and Ben M‘rad and Chalbi [42] at the Tunisian population; there is a correlation between the type of habitat and the practice of the consanguineous marriage.

![Fig. 1: Geographical location of El-Kala.](image)

(A) Location of El-Taref (Common Wilaya of El-Kala) in Algeria.
(B) Map of El-Kala.
(C) Location of the studied cities.
Fig. 2: Description of Sample according to the environment type (n = 80)

Table 01: Inbreeding rate (Generation of index cases and generation of their parents)

<table>
<thead>
<tr>
<th>Generation</th>
<th>Endogamy %</th>
<th>Exogamy %</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSC</td>
<td>61.25</td>
<td>38.75</td>
<td>100</td>
</tr>
<tr>
<td>GHP</td>
<td>98.67</td>
<td>1.33</td>
<td>100</td>
</tr>
<tr>
<td>GWP</td>
<td>92.21</td>
<td>7.79</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 02: Comparison of inbreeding rates (N_c = 80, N_p = 75, N = 77 and α = 5% = 1.96).

<table>
<thead>
<tr>
<th>Case VS</th>
<th>Father VS</th>
<th>Father VS Mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.75</td>
<td>4.57</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Table 03: Inbreeding rate (Generation of index cases and the generation of their parents).

<table>
<thead>
<tr>
<th>Generation</th>
<th>Inbreed (%)</th>
<th>Not inbreed (%)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSC</td>
<td>11.54</td>
<td>88.46</td>
<td>100</td>
</tr>
<tr>
<td>GHP</td>
<td>6.06</td>
<td>93.94</td>
<td>100</td>
</tr>
<tr>
<td>GWP</td>
<td>4.11</td>
<td>95.89</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 04: Breakdown of different types of inbreeding (Generation of index cases and ration of their Parents)

<table>
<thead>
<tr>
<th>Generation</th>
<th>DSM</th>
<th>DBF</th>
<th>DBM</th>
<th>DFS</th>
<th>UC</th>
<th>CIG</th>
<th>UI</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSC (%)</td>
<td>0</td>
<td>55.55</td>
<td>0</td>
<td>33.33</td>
<td>0</td>
<td>0</td>
<td>11.11</td>
</tr>
<tr>
<td>GHP (%)</td>
<td>0</td>
<td>75</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GWP (%)</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>75</td>
</tr>
</tbody>
</table>

Table 05: Coefficient of Inbreeding (Generation of index cases and Generation of their Parents)

<table>
<thead>
<tr>
<th>Generation</th>
<th>Coefficient of Consanguinity</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSC</td>
<td>0.47</td>
</tr>
<tr>
<td>GHP</td>
<td>0.25</td>
</tr>
<tr>
<td>GWP</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Table 06: Comparison of the inbreeding rate (N_c = 78, N_p = 66, N = 73 and α= 5% = 1.96)

<table>
<thead>
<tr>
<th>Index Case VS Father</th>
<th>Index Case VS Mother</th>
<th>Father VS Mother</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.14</td>
<td>1.69</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Table 07: Frequency (%) of the consanguineous marriages in various Arab countries

<table>
<thead>
<tr>
<th>Pays</th>
<th>Year</th>
<th>Frequency (%)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>El-kala (Algeria)</td>
<td>2012</td>
<td>11.54</td>
<td>Present study</td>
</tr>
<tr>
<td>Algeria</td>
<td>2007</td>
<td>38.08</td>
<td>Algerian National Statistics Office, 2007</td>
</tr>
<tr>
<td>Oulhaça (Algeria)</td>
<td>2013</td>
<td>36.07</td>
<td>Sidi-Yakhlef et al., 2013</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>1995</td>
<td>57.7</td>
<td>El Hamza et al., 1995</td>
</tr>
<tr>
<td>Bahrain</td>
<td>1995</td>
<td>32.0</td>
<td>Ministry of Health, 1997</td>
</tr>
<tr>
<td>E. A. U.</td>
<td>1997</td>
<td>50.5</td>
<td>Al-Gazali et al., 1997</td>
</tr>
<tr>
<td>Jordan</td>
<td>1992</td>
<td>51.3</td>
<td>Khoury et Massad, 1992</td>
</tr>
<tr>
<td>Kuwait</td>
<td>1996</td>
<td>36.0</td>
<td>Ministry of Health, 1996</td>
</tr>
<tr>
<td>Libya</td>
<td>1996</td>
<td>46.5</td>
<td>General People's Committee for Health and Social Insurance, 1996</td>
</tr>
<tr>
<td>Oman</td>
<td>1996</td>
<td>54.0</td>
<td>Ministry of Health, 1996</td>
</tr>
<tr>
<td>Qatar</td>
<td>1999</td>
<td>46.0</td>
<td>Ministry of Health, 1999</td>
</tr>
<tr>
<td>Sudan</td>
<td>1995</td>
<td>65.0</td>
<td>Federal Ministry of Health and the National Center for Health Statistics 1995</td>
</tr>
<tr>
<td>Syrza</td>
<td>1995</td>
<td>38.0</td>
<td>Central Bureau of Statistics, 1995</td>
</tr>
</tbody>
</table>
### Table 08: The effect of habitat type on Endogamy

<table>
<thead>
<tr>
<th>Type of habitat</th>
<th>Endogam Individuals</th>
<th>Exogam Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>14</td>
<td>25</td>
</tr>
<tr>
<td>P theoretic</td>
<td>15.1</td>
<td>23.9</td>
</tr>
<tr>
<td>Urban</td>
<td>17</td>
<td>24</td>
</tr>
<tr>
<td>P theoretic</td>
<td>15.9</td>
<td>25.1</td>
</tr>
</tbody>
</table>

### Table 09: The effect of the habitat type on consanguinity

<table>
<thead>
<tr>
<th>Type of habitat</th>
<th>Consanguineous Individuals</th>
<th>Non Consanguineous Individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>32</td>
<td>6</td>
</tr>
<tr>
<td>P theoretic</td>
<td>33.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Urban</td>
<td>37</td>
<td>3</td>
</tr>
<tr>
<td>P theoretic</td>
<td>35.4</td>
<td>4.6</td>
</tr>
</tbody>
</table>

**Conclusion:**

While consanguineous matings continue to be commonly practiced in several areas of Algeria, their health impact remains underestimated because of the limited number of epidemiological studies. A better understanding of the impact of inbreeding on the occurrence of some specific diseases may raise public awareness of the potential negative effects of intra-family marriages.

Our study showed that the population of El-Kala is endogamous while we were expecting to find an inbred population.

The average rate of endogamy therefore is very high, while the average rate of inbreeding in this population is low; the average rate of endogamy for the three generations (GSC, GHP and GWP) is high with a low degree of consanguinity.

We also found that the type of habitat (rural or urban) does not influence the structure of our population.

In perspective, we propose to perform more investigation in order to identify factors increasing the endogamy in the Northeastern Algeria.

**ACKNOWLEDGEMENTS**

Our sincere thanks go to the interviewed people on this study. Many thanks to Pr. Bairi from Badji Mokhtar University Annaba for his great help, to Dr. A Salhi and Mrs. Hakima for their collaborations and to all people whom have contributed for the development of this study.

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